PIPING STANDARD

Wood Contract No:	7650
Client Name:	INEOS
Project Title:	Project One
Project Location:	Antwerp, Belgium

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Section	Summary of Change	Rev No.
4.3	Add 7650-8550-65-100-0002 'Typical Instrument Pneumatic Hook Ups'	A4
4.3	Add 7650-8440-SP-100-0019, 7650-8820-IN-100-0002	A5
5.2	Add new bullet point defining requirements for connecting to modules	A5
5.2	Flanged connections in hydrocarbon and steam service to be minimised	A5
5.4.4	Deleted and referred to 7650-8440-SP-100-0007	A5
5.11.2	Added details for vents and drains where PWHT is applied	A5
5.15.1	Last sentence deleted	A5
5.16.3	Should statements corrected to Shall	A5
5.20	Air Piping/Instrument scope split clarified.	A4
5.29	Future space allocation clarified per tier/level.	A4
5.29	Clarification provided for future space, min pipe size and max span	A5
5.30	Clarification provided for future space	A5
5.32	Misplaced word 'discharge' removed	A5
4.3	Specification added	A6
5.3.1	Details added	A6
5.4.3	Change to second sentence.	A6
5.10	Addition of notes for quick action line blinds after Table 3.	A6
5.11.1	Last sentence changed.	A6
5.14	Deletion	A6
5.34.1	Figure 2 & 3 were Figure 1 & 2	A6
5.35	Second and last sentence added.	A6
5.37	Jacketed piping added	A6
Table 1	Revised table heading	A6
Table 6	Revised table note 3	A6

1. PURPOSE

This specification covers the requirements for design of piping on INEOS Project One located in Antwerp, Belgium.

The piping standard specifies engineering requirements and recommended practices for the design of piping systems and the layout of process plant for the project. This standard shall be used in conjunction with the referenced documents and together with the plant layout specification and piping material specification contains the general design and material requirements for process and utility piping systems.

2. SCOPE

The scope of this standard is to define the basic design parameters and standards for the design of piping systems and layout of process plant by FEED and EPC Contractor. This specification is for onshore plants only. The standard is not applicable for the following:

- Main pipelines
- Underground sewage and open drain systems
- Instrument piping
- Piping within the jurisdiction of national or local authorities
- Piping within the jurisdiction of ASME Boiler & Pressure Vessel Code

Component parts of piping systems, and in general their placement relative to each other shall be in accordance with project specific Piping & Instrument Diagrams (P&ID's). The project P&IDs and the Line Classification Lists provide specific piping layout or routing criteria for critical piping where necessary and shall form the governing criteria.

3. TERMINOLOGY

The following terms are used throughout the document:

May	A permissive statement; an option neither mandatory nor specifically recommended
Shall	Designates a requirement which is mandatory. Deviation will require approval via the formal process noted in 7650-8820-PR-100-0030, 'Technical Queries, Deviations and Waivers'.
Should	A specific recommendation where conformance is not mandatory

4. REFERENCE DOCUMENTS

4.1 General

The latest edition, issue or revision of applicable codes and standards current at the effective date of the contract shall apply. All piping systems shall meet the requirements of this document, other referenced Project Specifications, relevant Codes, Standards and Statutory Regulations (where applicable).

4.2 Codes & Standards

The following international codes and standards shall apply as relevant. Applicable versions are listed in 7650-8820-IN-100-0002:

Document Number	Title
Belgian & Flemish Legislation	
VLAREM II	
Best Available Techniques (BAT)	
BAT on Bunds (2019)	Beste Beschikbare Technieken (BBT) voor inkuiping env ul – en loszones bij bovengrondse opslag van gevaarlijke of brandbare vloeistoffen
American Society of Mechanical Engineers (ASME):	
ASME B31.1	Power Piping
ASME B31.3	Process Piping
ASME B16.5	Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard
ASME B16.9	Factory-Made Wrought Buttwelding Fittings
ASME B16.11	Forged Fittings, Socket-Welding and Threaded
ASME B16.20	Metallic Gaskets for Pipe Flanges
ASME B16.21	Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.34	Valves - Flanged, Threaded, and Welding End
ASME B16.47	Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch Standard
American Petroleum Institute (API):	
API STD 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
API STD 617	Axial & Centrifugal Compressors and Expander compressors
API STD 650	Welded Tanks for Oil Storage
API STD 661	Air-Cooled Heat Exchangers for General Refinery Service
API RP 686	Recommended Practice for Machinery Installation and Installation Design
National Fire Protection Association (NFPA)	
NFPA 30	Flammable and Combustible Liquids Code
NFPA 58	Liquefied Petroleum Gas Code

4.3 Project Standards

The following project standards shall apply as relevant:

Document Number	Title
7650-8110-PH-100-0004	Flaring and Venting Philosophy
7650-8140-PH-100-0001	Fire Protection Philosophy
7650-8140-PH-100-0002	Fire and Gas Detection Philosophy
7650-8150-SP-100-0001	Human Factor Specification
7650-8230-PH-100-0001	Piping and Plant Layout Philosophy
7650-8230-SP-100-0002	Piping Material Class Service Index & Gen. Notes
7650-8230-SP-100-0003	Piping Stress and Pipe Support Criteria
7650-8230-SP-100-0004	Plant Layout Standard
7650-8230-SP-100-0005	Manual Bulk Isolation Valve Selection
7650-8230-SP-100-0006	Standard Assemblies for Vents, Drains and Instrument Connections
7650-8230-SP-100-0016	Pipe Support Standard Basis of Design
7650-8230-SP-100-0018	Piping Material Classes
7650-8230-SP-100-0025	Underground Piping
7650-8230-54-100-0001	Typical Utility Station Arrangement
7650-8230-54-100-0002	Miscellaneous Piping Details (Sht 1)
7650-8230-54-100-0003	Typical Piperack Cross Section
7650-8230-54-100-0004	Std Minimum Elevations – Plant Structures & Equip.
7650-8310-PH-100-0001	Civil and Structural Philosophy
7650-8430-PH-100-0001	Mechanical Philosophy
7650-8440-SP-100-0001	Insulation for Piping and Equipment
7650-8440-SP-100-0010	Pressure Testing of Piping and Equipment
7650-8440-SP-100-0011	General Requirements for Pipework Fabrication
7650-8440-SP-100-0012	Controlled Bolt Tightening
7650-8440-SP-100-0019	Service Definitions and General Requirements
7650-8550-SP-100-0006	Instrument / Piping Interface Specification
7650-8550-65-100-0002	Typical Instrument Pneumatic Hook Ups
7650-8820-IN-100-0002	Standards Index
7650-8820-PR-100-0005	CE Marking Strategy
7650-8820-PR-100-0012	Compliance and Conformity Guidance
7650-8820-SP-100-0001	Basic Engineering Design Data (BEDD)

5. BASIC DESIGN OF PIPING

5.1 Pipe Sizes

Pipe sizes shall be specified as Nominal Pipe Size.

Minimum pipe size shall be NPS 1", with smaller sizes permitted only where specifically stated (e.g. instrument connections and steam tracing).

Pipe Sizes 1/2", 3/4" and 1 1/2" are non-preferred and shall not be used in any piping class, except where specifically shown on P&IDs and with prior agreement of the piping engineer and approved by IPMT.

Non-standard pipe sizes of NPS 1¼", 2½", 3½", 5", 7", 9" and 22" shall not be used in any piping class.

Pipe sizes larger than NPS 24" and up to 48" shall be standardised as follows: 24", 30", 36", 42", 48". For pipe sizes larger than 48", the contractor shall propose the required sizes to IPMT for approval and development of the pipe class. Where other sizes are shown on the P&ID they shall only be used where agreed with the piping and process engineers and approved by IPMT.

5.2 Pipe Flanges

Flange joints shall be kept to a minimum and only considered for specific applications:

- Incorporation of in-line piping and instrument components.
- Connection to vendor supplied equipment and packages.
- In galvanised and lined piping systems for shop-fabricated piping spools and for closing spools on screwed systems
- Provision to dismantle and maintain equipment (e.g. removal of machinery casings, shafts and rotors, S&T heat exchanger heads, vessel distributors and heater burners).
- Where frequent dismantling of piping is required for commissioning (chemical cleaning, steam blowing), plant operations, maintenance and inspection.
- Where removable spools are specified for positive isolation.
- Connecting to modules for low risk services (e.g. Instrument Air, Plant Air, Nitrogen, Demineralised water, drinking water, waste water, fire water, cooling water. For all other services, connections shall be welded for reasons of minimising fugitive emissions and/or because these are more susceptible for wear and leakage. Connections between PARs shall be welded for all services.

For hydrocarbon service flanged connections shall be avoided to the maximum extent to comply with fugitive emission regulations. For steam service flanged connections shall be avoided to the maximum extent to simplify plant maintenance requirements.

Flange guards or wrappers shall be fitted to all lines in acid, caustic, diesel or other corrosive services to ensure that leakage does not result in a spray pattern. No flanges are permissible where such lines run above personnel access areas (walkways and stairs) or cable trays.

Where electrical insulation kits and/or continuity bonding are required at flange joints, full details shall be specified by the process and electrical engineers.

Where air coolers are mounted directly above the piperack, no flanges in hydrocarbon lines shall be located in, or below, the piperack underneath air coolers or on the motor access platforms to minimise the possibility of flammable vapours being drawn into the air cooler above.

Consideration shall be given to positioning flanges outboard of the piperack at a minimum of 1m from the piperack column centreline.

Particular care shall be exercised in ascertaining the flange standard and rating when mating to (or replacing) existing installations and at the interface with equipment suppliers or other contractor's scope.

When connecting to flat faced flanged valves and equipment, flat faced (FF) flanges shall be used with full face gaskets.

The requirement for bolt tensioning shall be as specified by piping class, except where identified as necessary for lines having specific design conditions (e.g. cyclic services). These shall be clearly identified on piping deliverables to assure correct bolt lengths are applied. Refer to 7650-8440-SP-100-0012 'Controlled Bolt Tightening' for required torque values.

5.3 Smallbore Piping and Connections

5.3.1 General

Piping NPS 2" and below (including branch pipes for small bore connections) shall be considered as smallbore piping.

Smallbore connections are connections that have a branch pipe to mainline pipe ration of less than 10% and excluding connections that have a branch ratio greater than 25%. Refer to figure 1.

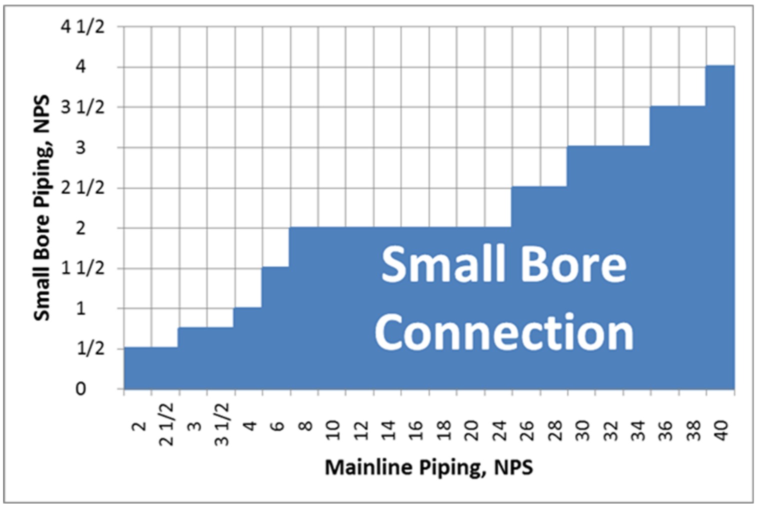

Figure 1 – Scope of Smallbore Connections (for mainline sizes up to NPS 40")

5.3.2 Small bore piping

Smallbore piping shall be connected by butt welds. Socket welds and screwed connections shall be kept to a minimum and in accordance with the applicable pipe class.

Changes in direction shall be made using short or long radius elbows.

Where small bore piping is connected to high temperature large bore parent lines at locations subject to significant thermal growth the smallbore piping shall incorporate adequate flexibility to absorb resulting movement between its connection point and any fixed supports. Adequate clearances from fixed structural features shall also be provided.

5.3.3 Smallbore connections

Contractor shall make a vibration assessment in accordance with EI AVIFF Guidelines and shall specify based within this assessment when small bore connections need to be braced.

Contractor shall submit a smallbore connection specification to IPMT for approval.

Contractor shall reduce the number of bracings by:

- removing redundant smallbore connections.
- changing small bore connection geometry when possible.
- shortening unsupported lengths as much as possible.
- maximising the diameter of the branch.
- minimising the mass of unsupported valves or instruments

If all measures have been taken to reduce the number of bracing, the design of the brace should ensure the following:

- Any mass at the free end of a cantilever shall be supported in both directions perpendicular to the axis of the smallbore connection.
- The bracing shall be in two planes, connected between the smallbore pipework and the main (parent) pipe.
- Bracing shall be designed so that all welds on the SBC are protected, not just the SBC to parent pipe welded fitting. This is usually achieved by bracing to the mass at the end of the smallbore connection.
- Bracing shall be from the main pipe, thus ensuring that the smallbore connection moves with the main pipe. Under no circumstances shall the connection be braced to local structure such as steelwork, decks or bulkheads.
- Any applied bracing must be sufficiently stiff.
- In the case where the smallbore connection has a geometry making it difficult to support, it should be re-routed to allow easy support.
- Any fastenings used should be designed to be effective under vibration (e.g. bolted clamps include anti-vibration washers (e.g. Nord-Lock™) or mechanical lock nuts.
- For pipe material or service conditions requiring PWHT, welds of bracing shall also require PWHT. As an alternative gusset lugs or plates shall be welded to the component to permit later welding of the bracing without further PWHT. This requirement shall be detailed by the CONTRACTOR and provided to IPMT for approval.
- Small bore connections < NPS 2” shall be braced in two places to avoid damage due inappropriate handling and use (e.g. using as a step-up.) Gussets material shall be the same the pipe material and as a minimum strip 30x 5 shall be used.

5.4 Design for Piping Fabrication

5.4.1 Field Welds

Field welds shall be positioned in piping systems to enable transportation of pipe spools from fabrication shop to site and to assist with erection. The shipping and transportation envelope dimensions shall be set by the construction engineer with field welds positioned wherever possible at a natural weld giving due consideration to the presence of flanged joints, pipe supports and the installation sequence where available. Whilst meeting the criteria above the identification of field welds shall be carefully considered such that the number of field welds shall be kept to a minimum.

Where pipe sizes are larger (typically NPS 24” and above) shipping methods become more demanding and may dictate the extent of prefabrication possible. However, it shall be ensured no damage occurs to transported spools, regardless of size.

5.4.2 Field Fit Welds

Field fit welds may include an additional length of 100mm of straight pipe in up to three planes to ensure alignment. These shall generally be minimised but incorporated where necessary and would typically include:

- Piping connected to rotating equipment to ensure strain is not present during equipment alignment.
- Connection to existing plant where site survey dimensional accuracy cannot be practically established.
- Specific instances to suit pipe erection and as identified with the construction engineer.

5.4.3 Elbows and Trimming of Fittings

Wherever practical, piping design shall be accomplished using standard 90 and 45 degree elbows. Lesser angles shall only be used by exception and achieved through trimming elbows radially. Where this is necessary the minimum distance between welds shall satisfy weld proximity criteria (ref Section 5.4.4).

Elbows fabricated from mitred sections of straight pipe shall not be used unless clearly specified in the individual piping material class.

Fittings other than elbows shall not be trimmed to achieve design angles.

5.4.4 Weld proximity

See 7650-8440-SP-100-0007

5.4.5 Piperack and Pipetrack Piping

Where significant quantities of straight pipe are to be installed within piperacks or pipetracks the installation method and use of random length and/or prefabricated spools shall be established in conjunction with the construction engineer. This will ensure piping is correctly designed, ordered and allocated for delivery.

5.5 Pipe Routing

Piping shall be routed consistent with the requirements of the P&IDs, be economic (through using a minimum length of pipe, number of fittings and welds) and provide sufficient flexibility to satisfy all pipe stress criteria. Cost effectiveness shall however not only consider individual lines, but more importantly, the optimisation of the surrounding plant area including; plant structures, common pipe supports, efficient foundations, underground service routes, etc.

Routing of critical lines, including those exposed to high pressures and temperatures, of large-size or of exotic material shall take precedence and be routed as directly as practical. These would typically include lines such as; tower overhead vapour lines, relief valve inlet lines, thermo-syphon reboiler circuits, pump suction lines and compressor inlet and discharge piping. Careful consideration shall also be given to lines with special flow conditions (e.g. two-phase, or slug flow) particularly with regard to slope and no-pocket conditions. It is generally effective to reconsider equipment location to meet the objectives for lines in these categories.

Where lines are not considered critical; they will normally be routed as general run pipe in “bands” (or “ribbons”) of piping, routed overhead within unit limits and on sleepers at grade in offsite/ utility areas and between units. These “bands” shall share common pipe support elevations; selected specifically for north-south and east-west piping (in principle matching the piperack), such that where pipes change direction their elevation change will alleviate difficulties in routing and distribution.

Minimum BOP elevations for general run pipe shall be 500mm for onsite areas and 600mm for offsite areas. This will allow adequate clearance for typical drain assemblies, but where high pressure and/or double block drains or drip legs etc. are required specific clearances shall be determined by individual case.

Piping shall be arranged to allow operation, inspection, maintenance and dismantling of equipment. There shall be sufficient space to enable mobile lifting devices to approach plant items and make lifts without obstruction and without the need to remove non-associated pipework.

Dead legs shall not be used unless for process reasons (Drip Legs). Dead ends in pipe runs shall be avoided. In cases where this becomes impractical and requires the extensive use of costly fittings (e.g. the sub-division of multi-branch headers to suit symmetrical flow) then extending and “capping” the header beyond the branch may be considered as an alternative. In these cases, the distance between the adjacent branch and weld cap shall be set at a minimum to satisfy weld proximity criteria and not be further extended to suit pipe support.

Piping and pipe supports shall be kept clear of all facilities including:

- Safety facilities (e.g. safety showers, eyebaths and firefighting equipment).
- Safety routes provided for personnel and vehicle access and egress.
- Electrical and instrument panels.
- Equipment maintenance and removal areas.
- Drainage manholes, cable trenches and buried lines.

Where piping passes through platforms, structural floors, walls and roofs penetration locations and details shall be agreed with the civil engineer.

5.6 Pipe Spacing

The minimum spacing between parallel run piping shall be based on staggered flanges with a minimum of 150mm longitudinal clearance between the flanges or insulation boxes and a minimum of 25mm clearance between outside of bare pipe or insulation, to outside of bare flange or flange insulation on the adjacent line (25mm minimum clearance also applies where lines cross one another). This shall be applied even where no flanges are included to allow a reasonable clearance for pipe installation, a general allowance for thermal movements and the installation of future flanged components. This shall be increased to 75mm (in both instances) for piping NPS 30” and above. The distance between pipes shall allow for the turning of a spectacle blind, if present.

Steam traced lines are to be spaced based on one line size greater to allow the use of over-size pre-formed insulation.

Spacing may need to be increased further to allow for:

- Changes in direction of pipe (particularly 45 degree sets).
- Where excessive lateral movements are anticipated (e.g. large stress loops).
- Where the layout requires adjacent flanges to be in-line and not staggered (e.g. at valve manifolds).

Where operating temperatures of adjacent lines are above and below ambient giving rise to opposing movements.

The spacing between the edge of pipe (or insulation) and adjacent item (e.g. structural member, fireproofing, cable tray, etc.) shall be no less than 50mm. This clearance is mainly required to satisfy constructional tolerance and shall be increased where necessary and particularly where significant thermal movement of larger pipe is anticipated.

5.7 Plant Access

5.7.1 Access Requirements for General Plant Items

This is a key issue and shall be agreed fully with IPMT prior to commencement of piping design.

Table 1 specifies the minimum level of access required to respective plant items and incorporates the following general philosophy;

- Equipment openings and operational valves require access from grade or, where elevated, from fixed platforms.
- Instruments require access from grade or permanent platform.
- Items requiring less frequent attention are acceptable with access from temporary manlifts or scaffolding, providing there is suitable clearance for such from below.

To ensure economy in overall plant design only the minimal level of access is necessary. However, access may be optimised across a number of plant items resulting in an improved method of access, without adding undue cost.

Table 1 - Access Requirements for General Plant Items

Item Accessed	Method of Access			
	Fully from grade or platform with stairway access	From platform with ladder access	From outboard edge of platform (Note 1)	From manlift and/ or scaffolding (Note 2)
Common Valves and Assemblies;				
Battery limit valves (and line blinds)	Yes	No	No	No
Emergency Isolation Valves	Yes	No	No	No
Sample piping	Yes	No	No	No
Control valves and assemblies	Yes	Yes	No	No
Relief valves and assemblies, inlet ≤ 3”	Yes	Yes	Yes	No
Relief valves and assemblies, inlet ≥ 4"	Yes	Yes	No	No
Motor operated valves	Yes	Yes	No	No
Piperack header block valves	Yes	Yes	Yes	Yes
Check valves	Yes	Yes	Yes	Yes
Line blinds ≤ 3”	Yes	Yes	Yes	Yes
Line blinds ≥ 4"	Yes	Yes	No	Yes
Clean–out points	Yes	Yes	Yes	Yes
Locked or car sealed valves	Yes	Yes	Yes	No
Operational vent and drain valves	Yes	Yes	Yes	No
Steam trap assemblies	Yes	Yes	Yes	No
Steam tracing manifolds	Yes	Yes	Yes	No
Categorised Valves - manually operated in piping systems (Note 3);				
Category 1 (all sizes)	Yes	Yes	No	No
Category 2, ≤ 12”	Yes	Yes	Yes	Yes
Category 2, > 12”	Yes	Yes	No	No
Instrumentation;				
Instrument isolation valves on equipment and piping	Yes	Yes	Yes	No
Temperature and pressure instruments	Yes	Yes	Yes	No

Item Accessed	Method of Access			
	Fully from grade or platform with stairway access	From platform with ladder access	From outboard edge of platform (Note 1)	From manlift and/ or scaffolding (Note 2)
Flow instruments	Yes	Yes	Yes	No
Flow instrument line mounted transmitter	Yes	Yes	Yes	No
Level gauges	Yes	Yes	Yes	No
Differential Pressure cell type level instruments (transmitter mounted locally by instruments at lower platform or grade)	Yes	Yes	Yes	No
Displacement type level transmitters, switches (nozzle or standpipe mounted)	Yes	Yes	Yes	No
Corrosion Monitoring Location (CML)	Yes	Yes	Yes	No
Equipment;				
Manways and hand holes	Yes	Yes	No	Yes
Shell and tube exchanger flanges	Yes	Yes	No	Yes
Air cooled exchangers motors	Yes	No	No	No
Air cooled exchangers header boxes	Yes	Yes	No	No
Reactors and adsorber catalyst loading flanges	Yes	No	No	No
Top of storage tanks < 4.5m dia, 6m high	Yes	Yes	No	No
Top of storage tanks $\geq$ 4.5m dia, 6m high	Yes	No	No	No

Table Notes;

1) Maximum of 300mm from platform edge and 1.5m above platform height.
2) Up to 4.5m above grade, providing there is clearance below for manlift or scaffolding, or up to 2.5m above major permanent platform.
3) Using valve categories ensures a consistent and effective approach in providing the correct access to manually operated valves. Where valve categorisation is not pre-defined on P&IDs, valves shall be reviewed with the process engineer (and IPMT as necessary) to determine categorisation prior to the design of piping systems. Within this standard categories are designated as; 1 - Regularly operated valves, 2 - Non-critical valves (only to be operated for shutdown activities).

5.8 Valve Ergonomics (Human Factors)

5.8.1 General

Against the aforementioned valve categorisation specific ergonomic requirements shall be considered in the detailed placement and orientation of valves. Detailed standards shall be developed as part of detailed engineering taking into account; valve function, operation frequency and operator type to satisfy IPMT ergonomic requirements and where necessary regional human factors.

Table 2 shall be considered as a general guideline.

Particular care shall be taken in determining height and orientation of valves in hazardous services (caustic, acid, high pressure steam, etc.) to protect the operator from eye level leakage. Also handwheels shall generally not protrude into accessways and shall be rotated parallel with the accessway, or shielded by other plant items, (e.g. equipment, structural columns or vertical piping) to prevent personnel injury. This is especially relevant where valve stems are higher than 1.5m and may present an eye or head hazard.

Table 2 – General Guidelines for Valve Ergonomics

<table>
<tr><th>Valve Type</th><th>Guidelines</th></tr>
<tr><td>Category 1 (all sizes)

Category 2 (all sizes)</td><td>Height; 500mm to 1.5m, Reach; max 300mm

Valves do not require permanent access</td></tr>
<tr><td colspan="2">Table Notes;
1) Whilst the table relates directly to handwheel operated valves, the intent of height and reach shall also be applied to MOVs with auxiliary handwheels.
2) Unless noted otherwise, dimensions equate to the height from floor level and reach from the edge of accessway to where the plant operator makes contact with the handwheel.
3) Height and reach dimensions relate to where valve stems are vertical and also where they are angled for accessibility.</td></tr>
</table>

5.8.2 Drain Valves

Drain Valves for level gauges on vessels should be located so that the liquid level can be seen easily from the drain valve position. All drain valves that are used periodically for blow down, including instrument drains, piping drains, and drains from major equipment, shall be independently routed to the sewer with discharge visible from the drain valve location. Hazardous material shall be released to a safe distance from the drain valve and operator.

5.8.3 Handwheel operated Valves

Clearance around valve handwheels shall be 100mm minimum from adjacent surfaces to ensure safe hand clearance.

Extended stem valves shall be minimised and used only where it is considered impractical to make the valve permanently accessible and subject to IPMT approval. Chain operators shall not be used.

5.8.4 Wrench Operated Valves

Shall not be used.

5.9 Valves and Isolation

Operating and block valves at equipment shall be provided consistent with the P&ID and be provided with car seals, locks or interlocks only as therein specified.

Additionally, the following shall be considered as general guidelines and provided consistent with the P&ID in accordance with 7650-8110-PH-100-0007 'Isolation Philosophy':

- Block valves shall be placed in branch lines from primary piperack headers serving groups of users, except where in the event of failure in a branch line, the main header can be shut-off without affecting unit operation.
- Block valves shall be fitted on the unit side of all overhead and underground process and utility lines crossing the unit battery limit demarcation. Line blinds and depressurising valves shall be provided on the unit side of the block valve.
- Equipment requiring isolation from service whilst the unit remains in operation shall be provided with line blinds and valves for positive isolation.
- All equipment shall be provided with blinds or means of positive isolation for inspection during a plant or unit Turnaround (TAR).
- Double-block valves shall generally be provided for Class 900 and above, in all pipe classes with welded-in valves and may also be required for lower pressure services, for example particular toxic and hazardous services.

The position of valves in overall piping systems shall be selected to minimise a build-up of static liquid or condensables against the valve sealing faces. This requires consideration to the flow direction. Piping shall locally free-drain away from valves where practical. This is particularly relevant in arduous services, for example where suspended solids are present.

Isolation valves used in conjunction with locally mounted flow and level instruments shall be placed in the vicinity and ideally at the same operating level and located such that the instrument is readily visible.

All valves shall be installed as flow marked to ensure that the valve closes against pressure, i.e. flow from under the disc.

Swing and dual plate check valves shall be installed in the horizontal flow position. Where the CONTRACTOR requires a vertical up flow installation, CONTRACTOR shall seek approval from the IPMT, such that a revised Valve Data Sheet can be developed. CONTRACTOR shall compile a table of check valve flow rates, and confirm the spring selection with the valve supplier, particularly for low flow rate conditions or vertical installation. Upstream and downstream minimum straight pipe requirements may vary and shall be as advised by the valve supplier. In advance of confirmed criteria 5D upstream and 2D downstream shall be provided at all check valves, to minimise the potential of piping re-design.

Valves in cryogenic service (inc. LPG and LNG) require additional consideration for piping design, including increased space arising from cryogenic insulation and valve orientation. Detailed standards shall be developed as part of detailed engineering and shall incorporate all special requirements for example; provision of integral depressurising vents within valve bodies, orientation with respect to flow direction, etc.

Locked Open (LO) or car sealed open (CSO) valves shall be installed with the valve stem in the horizontal plane only. This is to ensure failsafe operation through the prevention of a dropped gate case (caused by a broken valve stem) from restricting flow. In exceptional circumstances and by agreement (e.g. relief header battery limit valves) the valve stems may be orientated below the horizontal.

5.10 Line Blinds

Line blinds shall be provided to ensure positive isolation in the following applications and as indicated on the P&ID:

- Where piping systems or part-systems remain idle during operation of the balance of the unit.
- Where piping connects with equipment to enable purging/ steam-out operations and vessel entry to be performed.
- Where lines enter/leave process units (installed on the unit side of the battery limit block valve), except for lines carrying; utility air, steam and water.

Line blinds relate to fig '8' blanks, or separate spades and spacers, with the type dependent upon the piping size/ rating as specified in Table 3.

Table 3 – Line Blind Types

Rating (RF Flanges)	Figure '8' Size (NPS)	Spade and Spacer Size (NPS)
Class 150	≤ 12"	≥ 14"
Class 300	≤ 8"	≥ 10"
Class 600	≤ 8"	≥ 10"
Class 900	≤ 4"	≥ 6"
Class 1500	≤ 4"	≥ 6"
Class 2500	2"	4"

The use of quick action line blinds may be accepted on a case by case basis and prior approval of IPMT for specific purpose (regular changes) and on following condition:

- Mechanical locking is installed to avoid accidental operation (e.g. hit by scaffolding tube, use as a handrail,…)
- The quick action line blind has a mechanical positioning device that hinders to close the system if the sliding plate is not in the correct position (e.g. Safety Boss Onis or similar).
- Additionally a position sensor shall be installed with active loop back to control system.
- The quick action line blinds shall be tagged as special piping item and be part of a dedicated maintenance and inspection program.

The following notes apply to the positioning and incorporation of line blinds:

- Provision of access to line blinds shall be in accordance with Section 5.7.1.
- Any line blind item exceeding 25kg should be accessible by maintenance crane, or other temporary lifting equipment (e.g. 'A' frames at grade). By exception, where the blind remains inaccessible to such equipment, permanent lifting facilities shall be provided, including runway beams or hitching points.
- Items in this weight category shall wherever practical be placed in the vertical plane between flanges in horizontal sections of piping for convenient handling operations.

- Where vessel top nozzles are vertical, consideration shall be given to using “hooked” nozzles to enable the line blind to be installed directly on the vessel nozzle in the vertical plane within horizontal sections of piping. This arrangement shall also be considered for shell and tube exchangers with particular care given to the bottom nozzles to ensure convenient handling from above.
- Where equipment is close-coupled with no isolation valves (e.g. column and vertical reboilers), line blinds may not be required due to the operation and isolation philosophy. Where isolation is necessary consideration should be given to whether it is more practical to use a line blind or utilise a removable section of the interconnection and use temporary blinds to provide positive isolation.
- Where blinds are located between ring joint flanges a removable elbow shall be incorporated in the piping to enable the blind to be manipulated. This shall also apply to larger piping with raised face flanges where piping is considered insufficiently flexible.
- Spades without a spacer may only be applied in relatively flexible piping systems and shall not be used for spading rotating equipment in order to avoid distortion problems.

Separation of flanges for manipulation of line blinds shall be achieved using a proprietary flange spreader. Jackscrews drilled and tapped through flanges shall not be used unless specified by IPMT.

5.11 Vents and Drains

5.11.1 Operational Vents and Drains

The sizes shown in Table 4 shall all be considered as the minimum application size. These sizes will generally be reflected on P&IDs but may be increased for particularly onerous services such as liquid sulphur, slurry or heavy oils.

Table 4 – Vent and Drain Sizes

Header Size (NPS)	Vent and Drain Size General Applications (NPS)	Vent and Drain Size Long/Large Headers >150m
<2”	Same as line size	
2”” - 10”	1”	-
12” – 20”	1”	2”
24” – 30”	2”	3”
36” and above	2”	4”

Double-block valves shall be provided consistent with the P&ID for Class 900 and above and may also be required for lower pressure services, for example particular toxic and hazardous services. Where there are conditions that cause flash freezing of liquids on depressurisation the distance between valves shall be set such that the downstream valve remains operable, typically 1000mm minimum.

All low points in piping systems shall be provided with a valved drain to enable draining after hydrotest and at plant shutdown, unless the line can be otherwise drained (e.g. through equipment) and where there is no spading required at the equipment nozzle.

The valve outlet of vents and drains shall be fitted with a positive closure device (e.g. threaded plug or blind flange).

The drain connection shall not contain elbows (with the exception of drains on cryogenic lines where drain valve shall be in horizontal with stem vertical) and shall terminate at least 200mm above grade to enable rodding of drains or connection of flexible hoses.

5.11.2 Hydrostatic Test Vents and Drains

Vents and drains required for hydrostatic testing only are not shown on P&IDs. They shall be indicated on isometric drawings. The general rules are:

- Where no PWHT is required: ¾" thredolet with plug and shall be seal welded after testing has been carried out.
- Where PWHT is required: a weldolet with nipple, flange and blind

Assembly details are shown in 7650-8230-SP-100-0006 and 7650-8230-SP-100-0018.

5.12 Vent Piping to Atmosphere

Piping termination shall be specified on the P&ID as follows:

- Vent to Atmosphere at Safe Location – Used where there are traces of hydrocarbons or any toxic component present where the open-end pipe shall terminate in accordance with the requirements stipulated in Section 6 of 7650-8110-PH-100-0004 'Flaring and Venting Philosophy'. Venting of hydrocarbon vapour to atmosphere shall only be considered in exceptional circumstances as described in 5.1.2 of 7650-8110-PH-100-0004 'Flaring and Venting Philosophy'.

All vent pipes shall terminate with a 45° elbow with piece of pipe cut to 45° angle and shall be fitted with a bird screen with a mesh size selected to avoid potential blockage (approximately 20mm square weld mesh) and supplied by the mechanical contractor.

5.13 Strainers

For the purpose of this standard a "Strainer" is defined as a single layer metallic screen, intended to stop potentially harmful debris or solid process contaminants from entering rotating machinery or other sensitive equipment. Finer filtration of fluids may be required for process reasons, or to prevent plugging, and where this is the case the equipment selected will be classed as a filter and shall be a listed equipment item.

The following shall be considered as general guidelines and equipment provided consistent with the P&ID:

- Where protection of equipment is required downstream of rotating equipment a specific device shall be installed for that purpose. Generally, such equipment shall not rely for protection on the upstream pump or compressor strainers.
- Permanent strainers shall be provided with differential pressure instruments where specified.
- Where permanent strainers are supplied by the machinery vendor, upstream temporary strainers may also be installed when recommended by the vendor.

5.13.1 General

Detailed requirements for permanent strainers, including mesh type and aperture size, basket design, materials and scope of supply shall be developed by the contractor, in accordance with project specifications, as part of detailed engineering. Such requirements shall consider as a minimum, API RP 686, 'Recommended Practice for Machinery Installation and Installation Design'- Chapter 6 in addition to those specified herein.

All strainers, temporary or permanent, shall have an open area equal to 150% of the pipe open area as a minimum.

Flat plate temporary strainers shall not be used. They do not satisfy mesh open area requirements and require in-line spool removal to allow effective debris removal.

Commissioning shall select temporary strainers (Y & T type) as defined in 7650-8230-SP-100-0018 'Piping Material Classes'.

Piping design at all strainer locations shall allow for the removal of the strainer internals without the addition of temporary pipe supports and without disturbance to equipment alignment.

5.13.2 Pump Strainers

Strainers shall be located no less than 5D minimum between downstream side of mesh to pump suction nozzle, this may include flanges, elbows and reducers where present.

All strainers shall be located in the position indicated on the P&ID. In the case of horizontal suction pumps the strainer will be at the low point of the inlet piping with preferably the branch vertically down or rotated to where unrestricted basket withdrawal is possible. Where there are severe space limitations (typically on larger lines) consideration may be given to locating the strainer in a vertical leg immediately prior to the horizontal pipe run.

Generally, "T" or "Y" type strainers shall be specified for pumps, with "Y" type used for all permanent applications as they are generally more robust for longer operating periods. Inline cone type strainers shall only be used where specified by the IPMT.

Particular attention shall be paid to assuring access to the cover low point drain and to removal of the cover and strainer basket (e.g. clearances required from local pipe supports and plinths). For strainers with covers exceeding 25kg careful consideration shall be given to the use of permanent or temporary lifting equipment as appropriate.

5.13.3 Compressor and Turbine Strainers

Compressor strainers shall be located no less than 5D minimum between downstream side of mesh to machine inlet nozzle, this may include flanges, elbows and reducers where present. Strainers shall be located downstream of the primary block valve and any form of liquid trap in the inlet piping.

Strainers for compressors and turbines will normally be inline cone type. "T" or "Y" type strainers shall only be used when specified, supplied, or otherwise approved by the machinery vendor. Cone strainers shall be installed with the small end of the cone upstream.

Piping shall include a flanged spool or elbow spool to allow installation of the cone strainer. Where a permanent strainer is required any temporary strainer shall be installed in lieu of, or upstream of, the permanent strainer.

The rotating equipment engineer shall advise any vendor requirements relating to strainers. Where these requirements conflict with project standards, resolution shall be agreed with all parties.

5.14 Utility Stations

Utility stations shall be provided for general plant maintenance in accordance with the P&IDs and the following general requirements and standard drawing 7650-8230-54-100-0001 'Typical Utility Station Arrangement':

- Steam, plant air and water across grade and main levels of major plant structures such that equipment, instrumentation and piping assemblies are accessible using 15m length hoses. Where water service is required at high levels availability of sufficient pressure shall be confirmed with the process engineer.
- Steam and plant air at minor plant structures, only where maintenance activities are anticipated and items cannot be conveniently covered from other utility stations.
- Steam and plant air at vessel platforms where manways/hand-holes, instrumentation and piping assemblies are present. To minimise utility stations these can be placed at alternate platforms provided that a 15m hose can be conveniently lowered and used at the lower platform.
- Alternatively, multipurpose dry riser lines can be considered.
- Nitrogen and other services shall only be provided where specified on the P&ID.
- Sufficient free length shall be allowed for hose deployment (safe trailing and hose connection).

Adequate space shall be allocated local to all utility stations for coiling of hoses and storage on hose racks. Positions local to the entry/exit points of stairways/ladders and designated egress zones shall be avoided. The supply of hose racks to be determined on a project basis. Further detail can be found in the standard drawing: 7650-8230-54-100-0001 'Typical Utility Station Arrangement'.

Services shall be provided left-to-right in the sequence; steam, water, air, nitrogen ("SWAN") when facing the utility station.

Separate hose coupling types shall be provided for each fluid to assure provision of correct service. Coupling styles shall be approved by IPMT.

Utility stations shall be fed direct from main utility headers or sub-headers to maximise availability during shutdown periods.Sizes for initial pipe routing shall be in accordance with Table 6 with all final sizes confirmed by the process engineer.

Table 6 – Sizing Guidelines for Utility Station Sub-Headers

Number of Utility Stations	Minimum Sub-Header Size (NPS)
1	1"
2	2"
3-8	3"
>8	4"

5.15 Piping Design for Instruments

This section relates to issues that impact general piping design and further reference shall be made to 7650-8550-SP-100-0006 'Instrument/Piping Interface Specification'. Detailed standards relating to the piping/instrument interface and space reservation requirements shall be developed as part of detailed engineering in conjunction with the instrument engineer and including any specific instrument vendor requirements.

Orientation and location of instruments shall ensure both operational and maintenance access is provided and withdrawal space is adequate where necessary.

Where instrument flanges do not comply with the rating of the parent piping system they shall be marked as such on P&IDs.

Refer to Section 5.7.1 for instrument general access requirements.

With the exception of temperature instruments (ref Section 5.15.3) there is no restriction in the orientation of instrument tappings in vertical lines. Tapping orientations in horizontal lines shall be in accordance with Table 7.

Table 7 – Instrument Tapping Orientations for Horizontal Piping

Type of Instrument	Gas	Liquid	Steam
Local pressure gauge	Top	Side	Top
Panel mounted pressure gauge	Top	Side	Top
Pressure transmitter	Top	Side	Top
2003 voting system (Note 1)	Top	Side	Top
Analyser sample supply (Note 2)	Side	Side	Side
Analyser sample return	Top/Side	Top/Side	Top/Side
Temperature instruments (all types) (Note 3)	Top	Top	Top
Haze and colour analyser	N/A	Side	N/A
Gas Chromatograph	Side	N/A	N/A

Table Notes;

1) Typically three off linear tappings. All shall be at the same orientation.
2) Where a take-off probe is required the P&ID shall specify orientation, probe detail and any line routing requirements.
3) In areas of restricted access installation can be 60° angle from the top of pipe in order to provide enough clearance for removal.

5.15.1 Control Valve Piping

Regulating control valves shall preferably be located at grade or at first operating level of plant structures. Control valves shall be located in sight of any instruments or indicators where they are controlling the variable being measured. The exception is in services where condensate occurs where the control valve set will be self-draining. Control valve assemblies (sets) shall be provided as specified on the P&ID, with the control valve generally accompanied with block valves and a bypass to enable the removal of the control valve for maintenance during normal operation. In advance of final control valves sizes the following should be used:

- For lines up to including NPS 10" a control valve and bypass one-line size smaller than the parent line size.

- For lines NPS 12” and above a control valve and bypass two-line sizes smaller than the parent line size.

Size of the bypass line shall be identical to the manual bypass valve size which shall have the same CV value as the main control valve.

Steam control sets shall have the drip leg incorporated into the upstream side of the set, with the upstream block valve located in the horizontal pipework adjacent to the drip leg, such that condensate removal can be achieved with the upstream block valve closed. The bypass valve shall be located at the branch on the steam supply side of the line to avoid accumulation of condensate.

A bleed (drain) valve shall be located between the upstream block valve and control valve when specified as ‘Fail Open' and upstream and downstream when ‘Fail Close’. A downstream valve may also be required in dirty or hazardous service (e.g. benzene) on ‘Fail Open’ valves and where specified on the P&ID.

Flanged spools shall be provided between the control valve and isolation valves of a length sufficient to permit removal of bolts and for the inclusion of bleed valves. The spools shall also be easily removed by either “springing” the pipe (on smaller line sizes only) or by removing a flanged elbow where sizes are larger or where ring type joints are required by in the piping class. The control valve assembly shall be supported such that the remaining piping system is adequately supported when the control valve is removed.

Bypass piping shall be routed such that the bypass valve is readily accessible with sufficient clearance to enable the removal of the control valve and/ or its actuator.

Particular attention shall be given to the location and detailed design of piping associated with control valves subject to high pressure drops to address issues associated with vibration and noise, with the process engineer consulted as necessary.

The flange rating and facing for all control valves shall meet the requirements of the piping specification with a minimum rating of Class 300# up to 8”.

5.15.2 Relief Valve Piping

Bracing and supports for relief valves shall be designed to prevent vibration and over-stressing during discharge and to permit independent removal of the relief valve from the piping system. A guide and line stop which is capable of withstanding the relief reaction force shall be provided at the discharge of each relief valve.

Any relief valve exceeding 25kg should be accessible by maintenance crane. By exception, where the relief valve remains inaccessible to such equipment, permanent lifting facilities shall be provided, including runway beams or hitching points.

Relief valve sizes and inlet/outlet line sizes depend on line routing due to the pressure drops incurred. All routings are therefore subject to detailed review by process engineer to confirm final sizing.

The following notes may also apply to thermal relief valves from potentially blocked-in systems, with specific requirements in accordance with the P&ID.

1) Relief Valves Discharging to Closed Systems:

Relief valves in gas and vapour service shall be located at an elevation that enables the inlet and outlet lines to free-drain back to their respective source equipment and relief header to ensure condensing vapour does not form a liquid pocket (see also Section 5.22).

Isolation gate valves on the inlet and outlet of the relief valve shall have their stems preferably orientated in the horizontal plane. Block valve stems on the discharge side may be orientated below horizontal if space considerations prevent horizontal installation. This is to ensure failsafe operation through the prevention of a dropped gate case (caused by a broken valve stem) from restricting flow.

Individual relief valve discharge lines from adjacent equipment may be routed to a sub-header, providing the sub-header is of sufficient size that the relieving capacities of the valves are not affected.

Where relief valves are paired the discharge lines shall not be harnessed such that the flows are opposing into the two run pipe connections on the same tee. Whilst it is recognised that only one valve may be operational, this should be considered good practice as it suits all cases.

Relief valve discharge lines shall enter the top of relief headers at 90 degrees unless specified otherwise on the P&ID. Where an angled entry, 60 degrees (included angle) shall be used for fabricated branches, with 45 degrees only used for smaller discharge lines utilising proprietary branch fittings.

Relief headers and sub-headers shall have a fall of 1 in 500 minimum in the direction of flow. Relief valve discharge lines (entering these headers) do not require a positive fall but shall free drain to header.

2) Relief Valves Discharging to Atmosphere

Relief valve inlet lines shall free-drain back to their source equipment.

Where relief valves are designated on the P&ID ‘Exhaust to Atmosphere’, the vent shall be positioned such that it does not impinge on operational areas and routes.

Where relief valves are designated on the P&ID ‘Exhaust to Atmosphere at Safe Location’ they shall as a minimum satisfy the conditions below. Additionally, the requirement on the P&ID shall be subject to safety review to ascertain whether further requirements are necessary to mitigate any increased risk to personnel:

- For hydrocarbon service, in accordance with the requirements stipulated in Section 6 of the Flaring and Venting Philosophy ‘7650-8110-PH-100-0004’.
- For steam service, nominally they shall exhaust 3m above any platform within a horizontal radius of 7.5m. However, to address potential safety issues relating to large volume, high-pressure, high-decibel or boiling water release each discharge location shall be further reviewed.

Relief valve tail pipes shall terminate upwards and have the end of the exhaust pipe cut square to prevent additional lateral forces.

A 20mm diameter weep hole shall be drilled through the underside of the tail pipe at the lowest elevation to emit any rain or moisture. Where hot and/or otherwise hazardous fluid may be discharged during a relief situation, an elbow and/or length of NPS 1” pipe shall also be fitted to prevent impingement on operating areas.

All tail pipes shall be fitted with a bird screen with a mesh size selected to avoid potential blockage (approximately 20mm square weld mesh) and supplied by the mechanical contractor.

3) Bursting Discs

Where bursting discs are specified upstream (below) a relief valve the bursting disc carrier shall be installed in a vertical section of pipe (flow upward) to eliminate uneven corrosion caused by liquid pooling on the lower quadrant of the bursting disc.

5.15.3 Temperature Instruments

The thermowell mounting type shall be selected based upon the pipe class. A flanged mounting shall be used for the non-fugitive emission pipe classes, whereas welded type thermowells shall be used for piping classes within low emission or vacuum service. To ensure the correct mounting type is selected refer to 7650-8230-SP-100-0018 ‘Piping Material Classes’.

Thermowell installation shall be vertical on top of the pipe with a 90° insertion angle. In areas of restricted access installation is permitted with an angular position of 60° from the top of pipe in order to provide enough clearance for removing. Thermowells shall be installed in minimum NPS 4” line size; where the line size is less than 4” the pipe shall be swaged up to 4” for thermowell installation.

To allow test wells to be filled and retain a thermal coupling fluid, they shall be installed in accordance with Table 7 for horizontal lines. For vertical applications, they shall be installed at 90° from vertical, except if wake frequency analysis requires a different angle as confirmed by IPMT Instruments Group.

For flanged mounted thermowells the piping/thermowell connection shall be 150mm stand-out to give a standard instrument interface. Where this dimension differs (e.g. selected proprietary fittings, or over-thick insulation) the actual dimensions shall be agreed with the instrument engineer to ensure probe lengths are correct. Sufficient space shall be provided to allow for thermocouple withdrawal.

Refer to 7650-8230-SP-100-0006 ‘Standard Assemblies for Vents, Drains and Instrument Connections’ for further detail regarding thermowell mounting configuration.

Temperature instruments in vessels shall be installed in accordance with the project vessel instrument data sheet. Particular care shall be taken with the thermowell probe to ensure the following:

- Where the instrument is intended to measure the temperature of liquids on trays or within draw-off boxes the elevation and orientation of the probe is within the normal liquid level.
- Where the intent is measurement of vapour temperature the probe shall be above the high liquid level or in the vapour space as specified.
- The probe does not clash with internals at the orientation selected, particularly baffles, stilling wells, tray weirs, distributors and tray bubble caps.

5.15.4 Pressure Instruments

Pressure instruments in horizontal piping shall be installed in accordance with Table 7.

Pressure instruments in vessels shall be installed in accordance with the project vessel instrument data sheet. Where the instrument is intended to measure differential pressure, careful reference shall be made to actual instrument details to ensure pairs of nozzles are correctly orientated and aligned where necessary. Nozzle positions shall be agreed with the instrument engineer.

5.15.5 Flow Instruments

Piping containing flow elements and meters (including: orifice plates, venturi nozzles, venturi tubes and vortex meters) shall satisfy the minimum straight run metering lengths in accordance with 7650-8550-SP-100-0006 ‘Instrument / Piping Interface Specification’.

Flow elements and meters shall preferably be installed in horizontal pipe runs. Where installations in vertical pipe runs are necessary, process fluid flow direction shall be:

- Liquids, flow upwards

- Dry Gas and Dry Steam, flow upwards or downwards
- Wet steam, flow upwards

On horizontal lines the radial location of tapping points on orifice and venturi flow elements shall take into account fluid type and be in accordance with project instrument standards. Dual tappings may be required on the same flow element depending upon the number of connected instruments.

Space for close coupled (and line mounted) transmitters shall be available where required.

Where restriction orifices are included to control flow, upstream and downstream straight lengths shall be as specified on P&IDs. As a general guideline and especially for piping larger than 14” at least 1D upstream and 2D downstream of straight run piping shall be provided. Such applications are often subject to complex process calculation and piping design shall wherever practical allow flexibility for additional straight lengths to be incorporated.

5.15.6 Level Instruments

Instruments on vessels and tanks, including standpipes, shall be incorporated as defined on the project instrument vessel data sheets, positioned to suit vessel internals and ensuring the required access for operation and maintenance is provided. Where level gauges operate across large liquid ranges (typically mounted on vessel standpipes), individual gauges shall not penetrate platforms to ensure visibility is unhindered and clashes with gauge illuminators are avoided. Particular care shall be taken around transmitter housings, integral gauge glass illuminators and instrument heat tracing where present.

Level transmitters shall be visible from associated level gauges to enable calibration.

Standpipe flange connections shall be in accordance with the vessel specification and include NPS 2” minimum isolation valves at the vessel nozzles. The standpipe shall be NPS 3” minimum to enable effective connection of multi-branch tappings and shall be a minimum of Sch. 80 for carbon steel and Sch. 40S for stainless steel. The combined weight of the standpipe and attached instruments may require supplementary pipe support from the vessel wall.

Particular care shall be taken to ensure the correct positioning of radar and beam type level instruments on vessels, and to ensure sufficient clear space is available for withdrawal of their internals for maintenance.

Vent and drain connections from standpipes and instruments shall be as specified on the P&ID. This includes the requirement for isolation and permanent connection to open or closed vent and drain systems.

In cases where level instruments are mounted in piping systems they shall be installed in vertical sections and in accordance with the details defined on P&ID’s. The design shall be subject to approval by the process engineer.

5.15.7 Analysers and Sampling Systems

Analyser and sampling systems shall be as specified on the P&IDs. This shall include probe details where required (e.g. diameter, insertion length, tip profile).

The optimum position of analyser tappings and their relationship with the analyser equipment shall be agreed with the instrument engineer. Sample piping shall be a minimum practical length to reduce static inventory. Any sampling point that requires operators to take a local sample shall be accessed from grade or permanent platform with stairway.

5.16 Steam Piping

Requirements herein are established catering for a wide range of steam applications (generally LP, MP and HP steam in Classes 150, 300 and 600 respectively). Where steam characteristics become more extreme, requirements shall be modified accordingly to assure that accumulated condensate does not inhibit plant performance, or cause damage to piping systems or equipment through common problems such as erosion and water hammer.

Steam pipes shall have a block valve at the boundary of the process unit. Flanges shall be provided at these locations to allow for spading (spades or spectacle blinds) to isolate the steam systems during maintenance of the unit. Instrument connections for flow, pressure and temperature measurements shall be installed downstream of the block valves to the plant or unit. Vent facilities of sufficient capacity shall be installed to enable the pipes to be warmed up prior to commissioning.

For piping around steam turbines see Section 5.27.

5.16.1 Steam Headers

Providing steam piping is supported within the requirements of this standard, piping headers can be run horizontally without a positive slope.

Steam headers, sub-headers and drip legs shall terminate with a blind flange to enable removal of scale and debris during commissioning and prior to start-up unless the specification for the system is fully welded.

Branches shall be connected to the top of headers with primary block valves provided. These shall be in the horizontal with upstream piping free-draining back to the header.

5.16.2 Steam Condensate Removal

Condensate removal shall be achieved by using drip legs (“boots”), which incorporate a steam trap assembly in accordance with Section 5.16.3.

Steam headers (and sub-headers) shall incorporate a drip leg a minimum distance from the header end.

Where horizontal runs become long (typically in piperacks/tracks), additional drip legs shall be positioned such that there is a maximum of 50m between drip legs.

Low point pockets in steam lines shall be avoided, but where unavoidable, a drip leg shall be installed at the downstream end of horizontal runs prior to any valve or final vertical leg. Where steam lines rise from a horizontal valve manifold, additional drip legs may be required if there is a possibility that condensate may build up when in a no-flow situation. This is particularly important in cold climates where freezing may occur.

A drip leg shall be provided in “dead-leg” situations upstream of block valves, even if the piping free drains downstream of the valve, (e.g. steam-out, snuffing manifolds and steam control sets).

Drip legs shall be located such that they do not foul with pipe supports or the piperack structure due to thermal growth of the parent line.

In units which also generate steam there will be cases where steam headers (or parts of steam headers) may see reverse flow. These cases are generally not specified on the P&IDs and the process engineer shall be consulted to determine if additional drip legs are required.

All drip legs shall be provided with:

- A blind flange (as opposed to a weld cap) unless the system specification is fully welded. Primarily this enables removal of scale and debris during commissioning and prior to start-up.
- A separate connection at a slightly lower elevation than the steam trap take-off connection (~50mm) to enable blow-down at start-up without attracting debris into the steam trap inlet.
- In non-freezing climates and where the drip leg is inaccessible the blow-down line shall be routed to enable more convenient operation and isolation.

Minimum drip leg sizes shall be as specified in Table 8.

Table 8 – Minimum Steam Drip Leg Sizes

Steam Header NPS (D)	Drip Leg NPS (d)	Minimum distance from underside of header to centreline of trap take-off;
≤ 4”	= D	100mm
6” to 10”	4”	150mm
12” to 24”	0.5D (or, next pipe size up)	0.5D
≥ 30”	0.5D (or, next pipe size up)	400mm

Where projects are subject to non-freezing design criteria, steam traps may be substituted with an accessible manual drain in non-critical applications (e.g. steam at utility stations and immediately upstream of infrequently used steam-out connections).

5.16.3 Steam Traps

Steam trap assemblies shall be accessible in accordance with Section 5.7.1.

The requirement to collect steam condensate for re-processing shall be in accordance with the project philosophy and as indicated on the P&IDs.

Where condensate from steam traps is not collected the outlet lines shall be safely discharged locally to grade or to an underground drainage system. The condensate may require cooling through typically a “pebble pot” or water cooler dependent upon the drainage system material. This requires agreement with the civil engineer. Local discharge from steam traps shall be considered in remote areas where return may not be economical. This deviation requires IPMT approval where condensate collection is specified. Condensate discharge shall not impinge directly onto concrete paving, and care shall be taken to ensure operators are not scalded by condensate “splatter”.

Steam trap assemblies shall incorporate:

- Steam trap isolation block valves and break-out fittings as necessary to enable the steam trap to be maintained or replaced.
- A “prover” connection downstream of the trap and upstream of the isolation valve to witness steam trap operation.
- Where condensate is not collected, the steam trap “prover” connection and outlet isolation valves are not required.
- Where the drip leg is inaccessible, an additional valve shall be placed on the steam trap inlet line local to the drip leg and a “blow-off” connection provided immediately upstream of the steam trap isolation valve to remove condensate from the steam trap inlet line at start-up.

5.16.4 Steam Tracing

Steam tracing shall only be used following formal approval by IPMT.

Detailed standards for steam tracing, including size and number of tracers, limitations in tracer length and lift and manifold design shall be developed as part of detailed engineering. Additionally during detailed engineering tracer material shall be specified in the detailed piping material specification.

Sufficient space for steam tracing manifolds and provision of sub-headers (steam and condensate) shall be made during piping design to minimise impacts to platforms and general access during the latter stages of the project. Manifold style and any detailed tracing requirements shall be as agreed with IPMT.

5.17 Cooling Water Piping

Cooling water pipes ≤24” shall have block valves at the plot limit so that they can be isolated for maintenance while the cooling water system remains in operation. Branches to equipment shall be taken from the top of the header in order to avoid fouling of piping and equipment. Main distribution pipes shall have facilities at the lowest points to permit complete draining, venting facilities shall be provided to relieve air pockets.

Wherever practical, cooling water supply and return headers shall be routed within pipeacks. Where piping is larger (generally NPS 36” and above) consideration shall be given to distributing any major plant users from a below ground pipe system, with the remaining plant users distributed from piperack headers. Refer to Section 5.34.

Where ground conditions dictate and connecting piping is larger (generally NPS 18”) consideration shall be given to using bellows to connect underground headers to above ground equipment. Similarly, bellows should generally be used for the connection between cooling tower basins and cooling water pumps.

Small branches (NPS 2” and smaller) from the cooling water header shall in all instances be taken from the top of the header to avoid blockage. Larger branches may be taken from the top or the side of the header to suit specific layout requirements.

5.18 Potable, Demineralised and Service Water Piping

Branches NPS 2” and smaller, from headers shall be taken from the top of the header to avoid blockage. Larger branches may be taken from the top or bottom of the header to suit specific layout requirements.

5.19 Firewater Piping

Firewater systems, due to their criticality, shall be designed in accordance with local fire regulations in addition to project standards as appropriate.

Firewater systems are generally provided as ring mains and shall be fed from two directions such that individual sections can be isolated for repair or maintenance without loss of service to the remaining system. Each section of the ring main shall be isolatable using block valves and unless regulations dictate otherwise, no more than three individual items, such as monitors or hydrants, shall be fed from each isolatable section.

Fire-fighting equipment, such as hydrants, monitors, hose cabinets and foam injection manifolds shall be located at a frequency and proximity to equipment and other facilities to ensure coverage of any potential fire as agreed with fire protection engineer. Particular attention shall be paid to providing safe unimpeded access to and from this equipment.

Unless IPMT advises otherwise distribution fire-mains shall be as follows:

- Process, Offsite, administration and loading areas - distribution fire-mains shall be routed underground with particular care taken to ensure the system is generally flat and free of short-length low points, which would require frequent maintenance to ensure that silt or other debris does not accumulate. Firemains and spurs feeding fire-fighting equipment shall be protected from running fires where they cross open ditches or spillways.

Free-standing roadside items shall be adequately shielded from accidental collision whilst not compromising free personnel access by use of bollards or proprietary steel barriers.

All couplings intended for the connection of hoses or other fire-fighting equipment shall be compatible with existing or fire department equipment as applicable.

All pipe supports carrying fire water, pressurised firewater trigger systems and/or foam lines shall be fireproofed in accordance with project standards.

Foam piping protecting tankage or other facilities shall free-drain to the delivery points and/or back to the supply connection point to allow complete drainage of the system after use.

Provision and location of hose reels and portable fire-fighting equipment shall be as specified by project fire engineer.

5.20 Air Piping

Headers or manifolds shall be fitted with isolation valves and removable caps, plugs or flanges to allow for blowdown.

All branch lines from air headers shall be taken from the top of the header regardless of size.

Main distribution headers shall be routed to avoid pockets. Where this is impractical drain valves shall be provided to free the system of collected water and heat tracing may then be required in areas subject to freezing conditions.

Instrument air headers within process units shall be provided with valved take-off points fitted with a plug or blind flange. Branch lines for routing of air supplies to instrument distribution manifolds shall be run in piping in accordance with the P&IDs. The piping/instrument interface shall be as per 7650-8550-65-100-0002 ‘Typical Instrument Pneumatic Hook-Ups’.

Take-off points shall be provided at the following locations:

- Where these headers are routed in piperacks provide one take-off per piperack bay.
- Generally sub-headers within major structures shall be run vertically with two take-offs provided per platform level.
- Further and larger size take-offs shall be identified by instrument engineer as required.

Fire proofing of pipe supports carrying instrument air lines shall be in accordance with the requirements stated within 7650-8140-PH-100-0001 ‘Fire Protection Philosophy’.

5.21 Nitrogen Piping

Nitrogen has the potential to act as a lethal asphyxiant by rapid displacement of oxygen, even where released in an open environment. Joints in nitrogen piping, and potential release points such as vents, drains, utility hose and purge hook-up points shall therefore be minimised and positioned with careful attention to escape routes.

Additionally, open vents from vessels, which may be subject to gas freeing using a nitrogen purge shall be terminated as “Vent to Atmosphere at Safe Location” and clearly specified as such on the P&IDs (see Section 5.12).

5.22 Vessel Piping

Generally vertical vessel piping shall be located radially around the vessel on the piperack side with instruments, manways and platform access on the opposing side. With the exception of particularly heavy wall and high temperature vessels piping shall be supported from clips welded to the vessel shell.

Piping and all nozzles shall be orientated and arranged in conjunction with vessel internals (e.g. trays, distributors, baffles, etc.). This is critical to equipment and plant operation and all nozzle and clip orientations shall be fully agreed with the vessel engineer prior to submission to the vessel vendor.

All vessel attachments and clips including the connected pipe supports and/or supporting steel shall be designed so that there will be no ingress of water under the vessel/piping insulation.

Particular piping configurations required to satisfy process flow conditions shall be specified on the P&ID. This would typically include pipe minimum straight lengths and specific alignments, which may apply to piping that connects to internal distributors and tray draw-offs.

Where vessel height is substantially higher than the general plant, vessel relief valves shall wherever practical be positioned at a lower platform elevation to minimise high-level operation and maintenance activities. Consideration shall be given to branching the relief valve inlet line en-route from the vessel overhead line and mounting the relief valves at either a lower cantilevered vessel platform or on a directly adjacent structure. In all cases the inlet and outlet shall free drain to the parent pipe and relief header respectively.

Piping shall be routed with adequate flexibility to accommodate design conditions for vessel and line growth, including where relevant, start-up and steam-out conditions.

Adequate space shall be allowed between adjacent lines and between lines and vessel shell and platform/ladder steel to give sufficient clearance for the installation of pipe supports, including springs where required, and insulation. The minimum clearance from back-of-pipe to outside of vessel shell shall be 450mm for non-insulated lines and 550mm for insulated lines. In the case of excessive insulation thicknesses (e.g. cryogenic services) and where the vessel has local protrusions (e.g. over-thick wall sections, stiffening rings, girth flanges, etc.) clearances shall be increased as necessary. See standard drawing 7650-8230-54-100-0002 ‘Miscellaneous Piping details’.

Wherever possible, smaller piping shall be grouped together, to suit installation and common pipe supporting (e.g. service piping to utility stations, instrument air, steam tracing manifold supply/return piping, nitrogen purge, etc.).

Valves and flanges shall not be located inside vessel skirts. Where there is a definite process/operational requirement to access the vessel lower head, consideration shall be given to supporting the vessel in an open structure, (structural table top or, on smaller vessels, supplying the vessel with legs).

Instrumentation shall be in accordance with Section 5.15.

The number and size of platforms shall be minimised, giving consideration to convenient vessel access/egress. Transition between ladders should be straightforward without undue traversing of platforms between ladder rises and with manways and instruments located further along the platform. Where this cannot be achieved extreme care shall be taken in the layout to assure that instruments do not block the main access/ egress route and open manways, including trailing cables, tool boxes, manway covers, etc., do not block access.

Vessel nozzles shall extend through top platforms to provide access to the flange and bolting for maintenance activities and spading. FOF to TOP shall be a minimum of an equivalent length of a nozzle rated WN flange plus 50mm. This is a key issue and shall be agreed fully with IPMT prior to commencement of piping design. See standard drawing 7650-8230-54-100-0002 ‘Miscellaneous Piping details’.

Where practical consideration shall be given to providing links between vessel platforms and those on adjacent structures and aircoolers where there are perceived operational benefits. Pressure vessels which are grouped together shall have platforms and interconnecting walkways at the same elevation. The number of stairways and ladders to the platforms shall be sufficient to meet safety requirements.

On vertical vessels removal of external items (relief and control valves, etc.) and internal items (trays, distributors, etc.) shall be achieved using permanent lifting davits unless IPMT dictates the use of mobile lifting equipment. Where practical a single davit shall be located at the top head platform such that all removable items are accessible and can be lowered to the drop-out area at grade without obstruction. Where vessels have a coned transition piece a second davit may be required with suitable platform laydown to enable transfer of items to grade to avoid top davits with excessive arm length.

Where vessels are pre-dressed, all items shall be installed prior to lifting (insulation, piping, instruments, platforms, ladders, cables, etc.). Items shall be kept clear from all transport and lifting devices including; transport saddles and restraint bracing, lifting trunnions/ lugs, tailing devices, spreader beams/cables and transport trailers. Only minimal finishing work shall remain after lift and ideally this shall be completed from an installed permanent platform to minimise site scaffold requirements.

5.23 Shell and Tube Exchanger Piping

Piping shall not run directly over channel/shell cover areas to ensure that maintenance handling facilities are not obstructed. Where necessary, flanged break-out spools shall be provided to permit removal of shell/channel covers and tube bundles. Piping shall be supported to enable removal of spools without disturbance of the pipe support system and without a requirement to temporarily support the remaining pipework.

Shell and channel box piping shall be provided with vent and drain connections unless it can be vented and drained via other equipment. Drain and vent nozzles on heat exchangers shall have a valve and a blind flange.

Heat exchangers in thermo-syphon re-boiler service are sensitive to pressure drop conditions and the exchanger location shall satisfy the specified elevation and be at a minimum distance from the associated column to ensure that shell side supply and return piping is as short as possible, with minimum elbows and no pockets in the vapour return line, whilst still meeting stress criteria. Piping shall be routed consistent with the requirements of the P&IDs, particularly where there are multiple shells and/or nozzles to ensure that equal flow distribution is achieved.

On vertical exchangers, piping shall be designed to ensure the safe removal and laydown of top and bottom covers and where required removal of the tube bundle.

Where vertical re-boilers and exchangers are close-coupled with columns whilst the connection between equipment will be shown on the P&ID the final piping design shall wherever practical ensure the exchanger is supported directly from the vessel to minimise issues associated with differential movements. This arrangement and the scope of supply shall be agreed with the vessel, process and heat exchanger engineers to ensure that responsibilities for the overall system, including field alignment, support systems, and steelwork attachments are adequately defined.

Where tubes are fixed the requirement to repair the tubes in-situ or to remove the entire exchanger for maintenance will dictate the piping design, including removable spools where required. In all cases space shall be allocated for the in-situ lancing of tubes and clearing of debris.

5.24 Air Cooler Piping

Consideration shall be given to any overriding process conditions such as; symmetrical flow, equal flow (“cascade”), gravity flow and valved bundle isolation. To achieve equal or near-equal, distribution through each bay of multi-bay airfin coolers the branch to each airfin nozzle shall comprise the same pipe length and number of elbows.

The philosophy regarding removal of tube bundles for maintenance (versus making repairs in-situ) shall be established with IPMT, including the requirement to provide piping break-out spools.

Pipe stress and support philosophy around aircoolers shall be set as part of piping design in agreement with the heat exchanger and structural engineers (including vendor approval where necessary). Considerations include:

- Aspects relating to split header boxes
- Tube fixed/ sliding ends
- Fan failure pipe stress impacts for uneven pass air coolers
- Potential to absorb pipe header thermal movements across multi-bay air coolers

Particularly for multi-bay air coolers, the preferred location of the upper pipe header is directly above and close-coupled to the upper nozzles to simplify the overall piping arrangement. Where air coolers have a horizontally split header box arrangement, the lower pipe header shall also be close-coupled if possible.

Where it is not possible to achieve a close-coupled arrangement (e.g. excessive header movements, non-split header boxes), individual nozzle legs shall be incorporated to give adequate piping flexibility.

Where the air cooler is not in condensing service and where there are a significant number of nozzles, consideration shall be given to placing the inlet pipe headers lower than the air cooler with the individual nozzle legs routed up-and-over to the inlet nozzles to negate the requirement for high-level pipe support.

Piping design shall ensure that header box plugs required for the rodding-out or plugging of individual tubes are not blocked.

Overhead piping from columns to air coolers shall be as short as possible to minimise pressure drops.

No piping shall be routed directly over air cooler tube areas.

Hydrocarbon piping shall not be positioned on the motor access platforms directly below the air cooler. This area may however be used for minor utility piping.

5.25 Pump Piping

Pumps are subject to NPSH conditions, therefore equipment and piping design shall as a minimum satisfy the elevation requirements as specified on P&IDs. Where necessary vessel elevations can be increased to satisfy headroom clearances and support requirements.

Suction piping is subject to gravity flow conditions and shall be routed to avoid vapour pockets. In exceptional cases and where this is not possible, consideration shall be given to installing facilities for the operational venting of vapour pockets. The requirement for such is dependent upon process engineer and IPMT review of the proposed pipe routing.

Complex routings shall be avoided to prevent unnecessary pressure drop, specifically local to the pump to avoid vortex formation and uneven flow characteristics.

Installation of centrifugal pump suction pipe size reduction shall be in accordance with Table 9.

Table 9 – Suction Pipe size reduction

Pump Configuration (Suction/Discharge)	Suction Piping Configuration	Reducer Type/Orientation
Front/Top and Side/Side	Pipe approaching pump from above	Eccentric/Top Flat (1)
Front/Top and Side/Side	Pipe approaching pump from below (2)	Eccentric/Top Flat
Top/Top	Pipe approaching pump from above	Eccentric/Side Flat (3)

Table Notes;

1) An eccentric reducer is specified to address differing pipe configurations. Whilst a bottom flat (or concentric) reducer may assume that venting can take place against the incoming flow in operation; the fluid type, flow rate and particularly the length of horizontal piping immediately upstream of the reducer may in fact cause gases to disengage and collect in the cavity formed (immediately upstream of the reducer), which may lead to intermittent gas release causing cavitation in the pump chamber.
2) Piping configuration used in minimal instances and with the full agreement of the process engineer and IPMT.
3) A concentric reducer may give better flow characteristics and may be used where practical. However, it is often necessary to use eccentric reducers on both suction and discharge piping to ensure sufficient clearance between the flanges and/or insulation of the increased line size piping. This also recognises that the decision to procure reducers will be made in advance of pump vendor drawing receipt.

Pump suction piping shall be provided with minimum straight lengths in accordance with API RP 686 or specific IPMT requirements. This will generally be an uninterrupted 5D of straight pipe at suction nozzle size unless specified otherwise.

Where double impeller or multi-stage pumps are specified, specific piping design requirements may be required including suction piping orientation, reducers and straight runs. See API RP 686 and recommendations therein.

Where pumps are identified by the process and/or rotating equipment engineer as operating under particularly critical conditions (e.g. low pump heads, unstable fluids), pump manufacturers may require specific piping configurations including increased straight pipe lengths making the piping design problematic. In such instance’s resolution shall be obtained on a case-by-case basis.

Piping shall be designed with sufficient clearance and provided with flanged break-out spools as necessary to enable removal of pumps, drivers and ancillaries, including systems associated with seal pots, coolers and sprinkler systems.

Pump strainers shall be provided in accordance with Section 5.13.2.

Pump suction and discharge isolation valves shall be located to enable convenient exchange between the operating pump and it's spare. Ideally these valves shall be operable from grade with consideration given to providing platforms where pumps become particularly large. Where there are multiple pumps in the same area such platforms shall be combined and provided with convenient stair access.

On particularly hot services and larger sized pumps, consideration shall be given to routing the pump discharge line downwards to pump centre line level (such that support of pump and piping are aligned in elevation) to prevent high nozzle stresses and minimise the use of overhead spring supports.

Suitable supports, guides and anchors shall be provided so that excessive weight and thermal stresses are not applied to the pump casing and nozzles and do not exceed the nozzle loads and moments allowed by the pump manufacturer. Grade level pipe supports local to pumps are to be adjustable type to facilitate flange alignment and shall wherever practical be on an integral extension of the pump foundation to avoid support issues associated with differential settlement.

More specialist pumps will have specific requirements and piping shall be provided consistent with the P&IDs and will need to be developed in consultation with the process and rotating equipment engineers. This may include:

- Slurry pumps may require specific pipework arrangements and the pump may need to be placed directly below the suction vessel to minimise flow interruption. This may necessitate spring mounting of the pump to satisfy stress requirements.
- Positive displacement pumps require overpressure protection. Pulsation dampeners may also be installed to smooth out the fluid pulse where required.
- Double-diaphragm pumps may be selected for use on sumps and the pipework may be subject to a maximum lift height beyond which the pump cannot self-prime.

5.26 Compressor Piping

Piping for centrifugal compressors shall be designed in accordance with API RP 686 to ensure that the configuration and length of straight pipe upstream of the inlet nozzle is adequate and does not adversely affect compressor performance. The rotating equipment engineer shall identify manufacturer's recommendations with respect to line routing and inspection requirements and also review the proposed line routing with the process engineer and IPMT prior to construction release. Machinery vendor approval may also be required to validate performance guarantees. To prevent fatigue failure of compressor piping, the effect of vibrations and pressure surge shall be considered.

Liquids shall be prevented from entering compressors and piping shall be arranged accordingly. This is particularly relevant where gases are at, or near, to their dew point, where it may be necessary to provide further liquid removal facilities. This will be dependent upon process engineer and IPMT review of the proposed pipe routing and in addition to the primary knockout drum this may then include:

- Thermal tracing of the suction line between the suction drum and compressor.
- A further liquid removal device fitted immediately upstream of the suction pulsation suppression device (surge bottle).

Where compressors are elevated and include a raised floor at machine level, piping should generally be run under the floor to avoid impacting machinery maintenance activities.

Piping shall be designed with sufficient clearance and provided with a minimum number of flanged spool pieces to enable removal of compressors, drivers and ancillaries.

Compressor strainers shall be provided in accordance with Section 5.13.3.

On reciprocating compressors, suction piping shall generally be routed to the top of the cylinder and discharge piping from the bottom.

Inter-stage and discharge piping shall be sufficiently flexible to allow expansion due to the heat from compression.

On reciprocating compressors particular consideration shall be given to the design of piping to address issues associated with vibration. This includes:

- Minimising dead-legs formed by closed valves and particularly the main suction and discharge isolation valves on spare machines.
- Routing suction and discharge headers on grade level sleepers up to the first piece of connecting equipment (e.g. suction KO drum or after coolers). Such sleepers shall be installed independent from the compressor foundation and compressor house structure.
- Branch connections shall be taken from the top of the header and kept as straight as possible between the header and compressor. The use of short radius bends or tees shall not be permitted due to poor flow characteristics.
- Incorporating recommendations where relevant from vibration analysis studies of proposed line routes, e.g. modified pipe routings, pipe support constraints and the addition of surge bottles.
- Where the entire piping system is subject to vibration analysis all small-bore branch connections and piping assemblies shall be braced in two planes at 90 degree separation.

5.27 Steam Turbine Piping

Piping for steam turbines shall be designed to ensure that the configuration and length of straight pipe upstream of the inlet nozzle is adequate and does not adversely affect turbine performance. The rotating equipment engineer shall identify any manufacturer recommendations and shall also review the proposed line routing.

The block valve on the exhaust line of a turbine shall be located local to the turbine.

Steam turbine inlet piping shall incorporate a convenient flange or break-out spool for the connection of temporary piping to enable steam line blowing during commissioning. This spool may also be used to allow removal of strainers supplied integral with the turbine. Warming-up facilities shall be provided for the turbine inlet piping and the turbine.

Turbine strainers, where not integral or otherwise supplied with the turbine, shall be provided in accordance with Section 5.13.3.

A drip leg shall be provided at the low point on the turbine inlet line immediately upstream of the block valve or the automatic start-up valve where the turbine is on automatic start-up. A drip leg shall also be provided at the low point of the exhaust line, downstream of the discharge block valve.

Steam traps may also be required for draining the turbine casing. Whilst these are often supplied by the turbine vendor condensate return piping may need to be provided in accordance with project requirements. Steam vents shall be routed to a safe location and shall not be combined with any lubricating oil, seal oil or process venting arrangements.

5.28 Fired Heater Piping

Pipe routing shall be kept clear of space required for tube withdrawal and maintenance.

Where fired heaters have multiple passes the feed piping shall be routed such that it is as symmetrical as is practically possible. Similar line length and fittings shall be used from the point where the flow splits to the heater inlets. Similarly, consideration shall be given to the outlet piping, as non-symmetrical piping may contribute to uneven heating, possible coking and overheating of tubes.

Snuffing steam valve manifolds shall be located at grade 15m minimum from the nearest fired heater wall and wherever practical upwind or crosswind and in a location with convenient operator access/egress.

Burner piping shall incorporate the following as required;

- Fuel gas lines shall be steam traced and insulated downstream of the condensate knock-out drum. Only if the fuel gas is completely dry (e.g. natural gas) can the knockout drums or tracing be omitted.
- Where heaters have bottom-mounted burners, the burner piping shall be routed ensuring that minimum personnel headroom is maintained throughout main operator aisles.
- Take-off connections for steam and gas burner piping shall be made from the top of headers.
- Burner piping and hand control valves shall be arranged identically at each burner, adjacent to the peephole, to avoid operator confusion. Controls shall be on the same side of the peep hole in each case (typically right hand side when facing the peephole).
- Piping to the burners shall include break flanges to facilitate removal of burners for maintenance.

5.29 Piperacks

The primary purpose of piperacks is to support interconnecting process piping, utility header systems and cable trays. Where the piperack also supports equipment, e.g. air coolers, deaerator drums, relief valve platforms, etc., reference shall be made to the relevant section. See standard drawing 7650-8230-54-100-0003 ‘Typical Piperack cross section’.

This section applies to main interconnecting piperacks, process unit piperacks and secondary piperacks and also relates to offsite elevated road crossings as required.

This section shall be read in conjunction with 7650-8230-PH-100-0001, 7650-8230-SP-100-0004 and 7650-8230-54-100-0003.

Longitudinal piperack column spacing shall be set to ensure that piping meets pipe stress and deflection criteria as per 7650-8230-SP-100-0003. Careful consideration shall be given to the following:

- A spacing of 6m is generally effective where it does not introduce the requirement for intermediate support beams.
- Increasing pipe sizes within racks if cost effective to avoid provision of extensive intermediate support beams (NPS 4” and above can be routed in a pipe rack with a span of 8m between columns without intermediate supporting beams. For smaller pipe sizes intermediate supporting is required).
- Where a piperack contains a significant quantity of smaller piping a spacing of 8m with an intermediate support beam may be more cost effective.
- The complexity of piping turnouts generally required throughout the piperack.

- Access required at grade for plant operations and maintenance is of sufficient significance to impact the longitudinal spacing.
- The benefits of not incorporating intermediate support beams at every level.

All piping shall be supported on pipe shoes, piping shall never be installed direct on the beam or on rubbing bars, U-bolt clamps are not allowed.

Major piperacks shall include 10% (ISBL) and 10% (OSBL) unoccupied future space at project execute completion.

This future space shall be calculated as a percentage of the total occupied width (E.g. A piperack consisting of 3 tiers with a width of 3 metres has a total width of 9 metres. 8 metres are occupied at the end of execute. An unoccupied space of 0.8 meter shall be foreseen. This is possible without any change to the design of the piperack as there is 1 metre not occupied.

The space needed for carbon capture ducting shall be assessed separately and plot space reserved accordingly. No added contingency for unoccupied future space is required for carbon capture ducting.

Pipe racks shall be engineered to allow for the additional load generated from this future space.

Additional considerations:

- Process services shall generally be placed below utility services in multi-tier piperacks, with particular attention given to flare and blow down systems, which will generally require a separate uppermost tier.
- Process and utility lines shall be routed in separate tiers to the maximum extent. In exceptional cases (e.g. when cost savings are relevant compared to good practice) process and utility lines may be routed in the same tier.
- Process services shall not be run on the top level to avoid additional lightening protection.
- Where lines carry corrosive fluids, they shall be routed in the lowermost tier in multi-tier racks.
- Utility headers shall be extended a minimum distance beyond the final take-off and terminate with a blind flange to facilitate initial blow-through and cleaning. This also enables future extension where this may be required. The header shall not be extended further to satisfy pipe support conditions.

A spacing of either 2m or 2.5m between piperack levels is typically used to give an effective and economical piperack design. This shall be developed during detailed engineering to suit piping turn-outs, stress loops, constructability and clearance from structural members. Where spacing in excess of this is being considered, the piperack design shall be carefully evaluated to ensure it is not over-designed across the entire unit. Where pipe sizes differ substantially between units the requirement to standardise spacing across all units, or a number of units, shall be carefully evaluated.

Rack elevations in the north-south direction shall be different from the east-west direction. The change of elevation allows the rack to be extended in future and will facilitate the locations of the piping on the rack. Similarly, if cross racks running out from the main rack are used, these should be run at a different elevation to avoid interference. The same change in elevation rules apply where a rack runs through 90°.

Larger-sized and higher temperature lines shall be placed towards piperack edges to enable stress loops to be incorporated. Additionally, and where practical, particularly large liquid-filled lines, such as cooling water headers and crude feed lines, shall also be placed towards the edge to minimise structural beam depths. Stress loops shall wherever practical be "nested" together and only cantilevered sufficiently outboard to make support from the longitudinal side beams possible. Stress loops will generally be positioned approximately mid-way between allocated pipe anchor bays and in positions where there are no significant connections anticipated with adjacent major equipment.

Piperack structure anchor bays shall be agreed with the structural engineer giving due consideration to pipe anchor, stress loop locations and access requirements at grade.

Generally piping shall not be supported on outboard cantilevers. An exception may be sloping lines such as flare and closed drain headers, where their routing and support would otherwise become uneconomical.

Piping, including flare and blow down headers, shall not be routed directly above piperack columns. This also applies to engineered and site run cable trays, small bore pipe and tubing.

Piping and cables shall not be routed vertically through piperack levels to prevent interference with installed and future piping. This includes minor field-run items such as steam tracing supply and return lines, flow element transmitter tubing, sample lines and individual signal cabling.

Cables at the end of piperacks shall be routed such that they do not interfere with grade access or prevent the possibility of piperack extension and to suit the sequenced installation of rack piping.

A minimum spacing of 1m between cable racks shall be ensured to allow for the installation of a continuous permanent walkway.

Where piping runs vertically immediately outboard of the piperack, a common back-of-pipe (or back-of-shoe) shall be used and typically placed 1m from the centre of the piperack column line. The resultant void (between edge of piperack column and back of pipes) shall be reserved at each main piperack level for the routing of smaller interconnecting cable trays.

Where header block valves are required on take-offs (and there are no access platforms in the vicinity) they shall be located in the branch line immediately outboard of the piperack edge. This reduces the requirement for personnel to enter the piperack and enables safe access from manlifts or scaffolding. On instrument air headers the block valve shall be placed directly on the header branch, hence the header shall be placed towards the piperack edge, such that valves remain reasonably accessible.

Wherever practical the piperack design shall incorporate a vertical section to include the battery limit isolation valves. This arrangement will allow safe permanent access for spading, pressure/ temperature measurement and depressurising of the system. As an exception, flare headers may run through the battery limit area maintaining slope requirements with valve stems at or below the horizontal.

The space underneath the unit piperack is generally reserved for plant maintenance access and shall remain clear of obstruction. This is a key issue and shall be agreed fully with IPMT prior to commencement of piping design. Plant facilities may be placed in this area where space outside of the piperack is not available and provided that hydrocarbon flanges are not installed directly below air coolers (ref Section 5.2). This may include:

- Piping control valves and manifolds etc.
- Junction boxes, welding outlets, lighting panels etc.
- Flow measurement devices in piping traversing under the lower piperack level.

- Sample connections and panels.
- Utility piping assemblies (steam tracing manifolds, steam traps, utility stations).

5.30 Pipetrack Piping

In offsite areas where practical, piping shall be located on pipetracks at grade with major overhead piperacks minimised and limited primarily to piping that requires routing without pockets, such as flare and vent headers. Pipes shall be set at a common support height to provide sufficient clearance for drain connections and steam drip leg assemblies. It is generally acceptable for changes in direction to be accomplished by flat turning.

Pipetracks shall generally comprise concrete sleepers complete with steel insert at point of support and be full-width with consideration given to adding part-width sleepers to provide intermediate support in cases where smaller line sizes are present.

All piping shall be supported on pipe shoes, piping shall never be installed direct on the beam, sleeper or on rubbing bars, U-bolt clamps are not allowed.

Consideration shall be given to thermal expansion resulting from process or climatic conditions and where possible this shall be accommodated by the inherent flexibility of the pipe routing. Where loops are unavoidable they shall be sized and positioned to minimise the number of liquid pockets.

Major pipetracks shall include 10% unoccupied future space at completion of execute phase.

5.31 Tankage Piping

All piping shall run above ground, supported on concrete or steel sleepers. All piping shall be supported on pipe shoes, piping shall never be installed direct on the beam, sleeper or on rubbing bars, U-bolt clamps are not allowed.

5.31.1 Isolation Valves

All storage tank positive isolation valves shall be located on the tank nozzles. Any further valves required in main process lines shall be located outside the bund wall and be readily accessible.

Where there are multiple-tanks within the same bund area tank codes generally require allowance for failure of the largest tank only. In these instances, and where tanks are in the same service, the requirement for and position of valves for emergency isolation shall be carefully considered to ensure that tanks in the same service cannot free-drain through the failed tank thus exceeding the bund capacity. This may impact the emergency shutdown philosophy and shall be discussed with the process engineer.

5.31.2 Pressure Relief

Sections of lines that can be isolated by block valves and that are carrying products having a flash point of 65°C and below shall be safeguarded against excessive pressure caused by sun heating, by means of pressure relief valves.

Sections of lines that can be isolated by block valves and that are exposed to sun heating or steam-tracing heat shall be safeguarded against a pressure rise above the maximum allowable working pressure, by means of pressure relief valves.

When such relief valves are located inside the tank pit or bund, these shall be installed in a by-pass across the block valve of the tank. Relief valves on isolated line sections are not required when the line is connected to conical roof tanks. Instead a 1” by-pass line leading back to the tank, with an inner pipe relief under the cone roof, shall be installed. However, this type of pressure relief shall not be installed on suction lines to tanks.

In all cases, the relief valve of an isolated line section shall discharge into the tank drainage system or contaminated sewerage system. For toxic chemical service the above precautions should be considered in consultation with specialists.

5.31.3 Pump Suction

Pumps selected for tankage service shall not have top suction nozzles. Any deviation from this shall be resolved with the process and rotating equipment engineer.

Pump suction lines shall take precedence in tank areas as they are subject to NPSH and gravity flow conditions and preferably the entire line should free-drain from the tank to the pump. A combination of bund wall penetration and/or tank elevation adjustment may be employed to achieve this.

Suction lines can be particularly long in tankage areas and where free-draining is not practical facilities for the venting and draining of any resulting vapour and/or liquid pockets shall be agreed with the process engineer. See also Section 5.25.

5.31.4 Bund Walls

Bund walls are generally of either earthen construction with sloped sides or vertical reinforced concrete walls.

Where walls are of earthen construction uninsulated pipe may pass directly through the wall but shall be coated and wrapped in accordance with project specifications for the protection of underground metallic piping. Insulated pipes such as steam supply for heating coils shall not pass through bund walls.

Where bund walls are made of reinforced concrete all piping shall pass above the wall with the possible exception of pump suction lines where there is a requirement to satisfy criteria in Section 5.31.2.

To maintain full integrity of concrete bund wall penetrations a proprietary “puddle” flange shall be used which fully anchors and seals the pipe. Supply and installation of the “puddle” flange shall be considered in the design and alignment of the piping system giving due consideration to the planned bund wall completion date. Except where specifically directed by IPMT, the use of proprietary flexible sealing “gaiters” shall be avoided due to potential issues relating to fire proofing, life cycle inspection and replacement effort.

To minimise risks piping not directly associated with the tankage contained in a bund area shall not be routed in or above that bund area.

5.31.5 Settlement and Deflection

Forces imposed on tank nozzles shall be controlled through anchoring lines at or immediately adjacent to the bund wall and providing inherent flexibility in the piping routed within the bund.

Where tanks are not on piled foundations spring hangers or spring supports shall generally be avoided where piping displacement can be adequately controlled by:

- Extending the tank foundation local to major process piping nozzles to accommodate the first pipe support, thus minimising nozzle loadings associated with tank settlement.
- Placing the first support a maximum practical distance from the tank to accommodate rotation of nozzles due to tank bulge.

- Use of proprietary 'low type' tank nozzles where the design is inherently stiff, thus limiting bulge.
- A programme of water-fill cycles in conjunction with hydrotest to maximise tank settlement prior to final piping hook-up.

Predicted settlement and solutions to minimise the impact on piping systems shall be determined in agreement with the civil, vessel and construction engineer.

5.32 Piping for Road and Rail Loading

Piping layout for loading and unloading facilities will be governed by the type and number of loading arms, and method of operation.

Where there are multiple loading bays; piping within the facility will be elevated on a piperack and loading bay gantry regardless of the type of arms being used. Minimum headroom shall be 6m unless specified otherwise. Where below ground routing is required/approved by IPMT, piping may either be direct buried or run in sand filled concrete trenches to avoid hazardous gas traps.

All such requirements shall be clearly defined by project and incorporated in detailed piping design as appropriate.

Where a battery limit valve station is specified it shall be located at a minimum practical level from grade, local to the facility fence line.

Vapour return lines are frequently required from loading facilities and such lines may require similar routing to flare lines, with regard to free draining and continuous slopes as specified on the P&ID.

For loading/unloading purposes loading arms with swivel joint piping can be used. The piping between a loading arm connection and manifolds/headers shall be designed with a slope towards the manifold (self-draining).

Gantries carrying the filling lines and filling platforms with filling manifolds shall be designed paralleled to each other and branch off at an angle to the main headers. The loading/unloading lines for different products to and from a jetty are generally connected to a header or headers located at the loading end of the jetty. All headers on jetties should be provided with a sample connection.

Piping on jetties shall not be smaller than 2" except for instrument, vent and sample connections. Attention should be paid that quantity metering devices, including their filter and deaerator, are easily accessible for operation and maintenance. The outlets of de-aerators shall be provided with flame arrestors.

Emergency isolating valves shall be provided in each loading line, at a safe distance. A check valve shall be provided in each unloading line at the manifold. Adequate provisions for firefighting shall be made.

5.33 Scraper Launcher and Receiver Piping

Typically piping feeding or leaving a process facility will be designed in accordance with ASME B31.3 along with associated valves and balance lines etc. with pipelines in accordance with the relevant ASME code as specified on the P&ID. Where the pipeline is above ground a suitable local anchor will be required to protect the equipment from thrust forces.

Where lines within a facility are specified as "scrapeable" careful attention shall be given to the piping design. This may include the requirement for full bore valves, "barred" tees to control scraper route and longer radius elbows (typically 3D or 5D) where other than spherical scrapers are to be used.

Where the use of temporary launchers or receivers is specified the connection shall be provided on the pipe axis with valves and isolation as specified on the P&ID.

5.34 Cryogenic Piping Systems

A proper recognition of the design requirements for these systems may substantially ease the installation process and provide a system that satisfies plant operation and maintenance activities. The main issue to consider is the increased space requirements arising from cryogenic insulation and valve orientation.

5.34.1 Valve Orientation

Valves used in cryogenic liquid service, particularly gate and globe valves, should be oriented in the following ways to protect the valve packing from extremely low temperatures.

- Extended bonnet valves in cryogenic liquid service operating at temperatures from -20º C to -50º C shall be installed with the valve stem vertical or with a maximum inclination of 60 degrees from the vertical (Ref Figure 2).

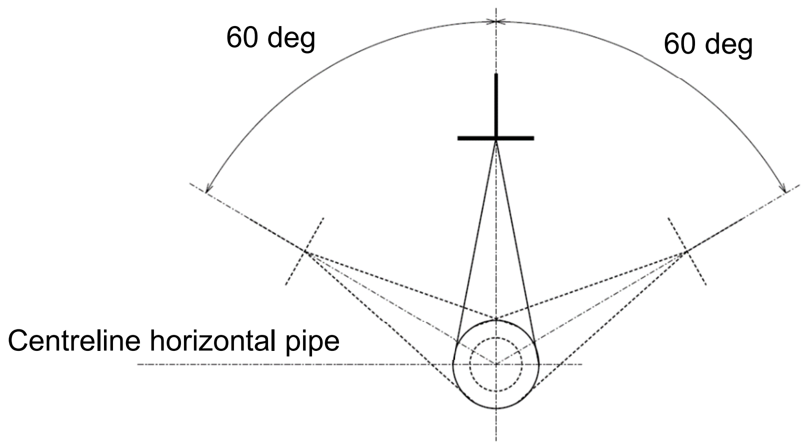

Figure 2: Valve Stem -20º C to -50º C

- Extended bonnet valves in cryogenic liquid service operating at temperatures from -50º C to -200º C shall be installed with the valve stem vertical or with a maximum inclination of 30 degrees from the vertical (Ref Figure 3).

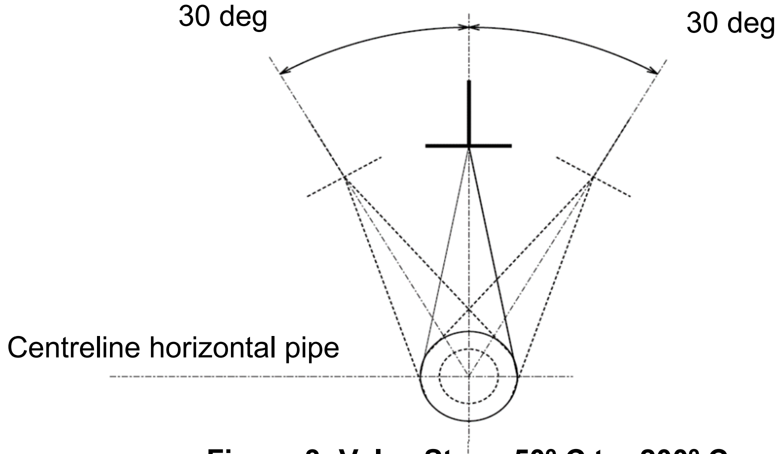

Figure 3: Valve Stem -50º C to -200º C

- Drain valves with extended bonnets in cryogenic liquid service operating at temperatures from -20º C shall be installed in the vertical position.

Valves in a 'no flow' connection (such as vents and pressure gauges), where the trapped gas accumulation protects the valve packing from low temperatures, may be installed with the valve stem in the horizontal position.

5.34.2 Cryogenic Insulation

Cryogenic insulation systems should be used to insulate piping and equipment with operating temperatures down to minus 170º C with ambient air temperatures up to plus 40º C and dew points as high as 1.5º C below ambient (due to high humidity).

Space should be allocated for the installation of valve and flange boxes. The increased space required for valve and flange boxes is due not only to large insulation thicknesses, but also allowances for maintenance considerations (i.e. bolt withdrawal) and the physical size of the valve body due to the extended bonnet.

When using cryogenic insulation, each time that positive isolation is required, the valve box must be removed and re-constructed after the work is complete. For cryogenic piping systems a critical review should be carried out as to the likely frequency of isolation and consideration given to a separate flange set for the spade / spacer. Where pipe specifications for smaller pipe sizes call for spectacle ('Fig 8') blinds, this should be challenged since they are more difficult to provide insulation boxes for.

Further detail regarding Cryogenic Insulation in Piping Systems can be found in 7650-8440-SP-100-0001 'Insulation for Piping and Equipment'.

5.34.3 Pipe Supports

The design of Pipe Supports used in cryogenic piping systems should follow the requirements specified in 7650-8230-SP-100-0016 'Pipe Support Standard Basis of Design'.

5.35 Underground Piping

Underground piping is defined as direct-buried piping intended for installation by the civil contractor and generally includes only all pressurised utility piping and firewater piping.

Underground process Piping shall be avoided and subject to case by case evaluation and approval.

Sufficient space shall be allowed for underground piping for excavation, temporary wall retention, piping installation and back filling operations with minimum clearances from foundations agreed with the civil engineer.

Corrosion protection of direct buried metallic piping shall be applied in accordance with project specific standards.

Where utilities are distributed as an underground system, all battery limit block valves and instruments shall be installed in valve pits. Attention shall be given to the manipulation of any line blinds due to the rigidity of the underground piping system.

Where an individual pipe crosses under a road it may be direct buried with a nominal cover of 1m with final cover as agreed with the civil engineer. Where the pipe is insulated the following shall also be considered:

- The carrying sleeve shall be buried to the same minimum cover height
- Suitable supports shall be provided within the sleeve in accordance with maximum span tables.
- The pipe shall be pre-tested and pre-insulated prior to insertion.
- Sufficient clearance shall be provided at one end of the sleeve to allow insertion of the pipe length.

Large-sized underground piping may require permanent manway access for inspection and maintenance purposes. This requirement and the number required shall be agreed with IPMT prior to commencement of detailed piping design.

Where underground piping connects to above ground facilities the interface connection shall be flanged with a face of flange elevation a minimum of 300mm above grade. Detailed standards shall be developed as part of detailed engineering taking into account transition between different materials and electrical isolation.

For further details of buried piping refer to 7650-8230-SP-100-0025.

5.36 Piping Modifications for Existing Plant

Generally P&IDs will only show the process intent of making connection to the existing piping system. The piping design shall satisfy this intent whilst also providing an effective solution that considers the constraints associated with construction activities on live plant and during plant shutdowns of typically limited duration.

The design, supply of materials, and installation of piping will be dependent on the number, timing and duration of shutdowns available for piping installation. The impact of these issues and any limitations on the extent of work permitted within the live plant shall be agreed with IPMT at an early stage.

The piping tie-in defines the connection point on the existing piping system. This connection shall be performed avoiding the requirement for gas freeing, hot-work and testing wherever possible.

This shall be achieved by considering the following options in order of priority along with the criticality and hazardous classification of the service concerned;

1. Connection to be made at existing flange or screwed joint to minimise the requirement for gas freeing and retesting of the existing piping systems. This may require the replacement of a short flanged or screwed section of existing pipework.

2. A welded connection positioned in a suitable section of existing pipework to minimise the level of isolation required for gas freeing and retesting. Welds to existing piping shall be positioned wherever possible to avoid the heat affected zone (HAZ) local to existing welds, using minimum criteria as specified in Section 5.4.4.

3. Tie-ins that involve hot cutting may only be used where the existing piping system can be completely drained and proven gas freed. Piping with pockets (e.g. valve recesses, fluid traps caused by orifice plates and deflections causing low points, etc.) shall be carefully considered.

Use of the following procedures shall only be considered where other methods have been fully investigated and found to be impractical.

- Hot taps and other tie-ins that involve hot work on live systems (e.g. welded split-tees and set-on branches).
- Stopple plugging via hot taps to allow installation of a permanent or temporary bypass or to limit gas freeing.

Where tie-ins are identified requiring hot taps and/or stopple plugging project shall carefully consider the use of a third-party specialist contractor.

Tie-in methods involving mechanical sealing, such as bolted split tees shall not be used.

The accuracy of new piping systems is dependent on the reliability and accuracy of the available existing plant information, the method of site survey and the thermal condition of the plant at the time of survey. In all cases piping design shall allow for adjustment during construction through the provision of field welds and field fit welds as appropriate.

Welded tie-ins to vessels and tanks shall be in accordance with the relevant vessel standards and shall in all cases be the responsibility of the vessel engineer.

5.37 Jacketed Piping

Contractor shall provide detail drawings and technical specifications for the design and fabrication of any jacketed piping for IPMT review and approval.

Contractor shall ensure the following sections are fully detailed.

5.37.1 Design

Core and jacket pipe shall be assigned separate line numbers.

Contractor shall consider the following design criteria for the core pipe

- Internal + external design pressure.
- External design pressure + vacuum.
- Hydrostatic pressure test of the jacket.

Contractor shall consider external corrosion of the core pipe.

Contractor shall consider and assess stress due to differences in thermal expansion of core and/or jacket pipe when selecting materials or calculating allowable stresses.

Contractor shall detail the drain and venting requirements for both core and jacket pipe.

5.37.2 Fabrication

Contractor shall detail the method of closing the jacket (including details of component, material and weld detail). Cold forming of pipe or fittings shall not be used.

Contractor shall detail the design of all core to outer jacket branch arrangements relative to the core pipe (Include details of Core and outer branch component: tee, olet, pipe, materials, weld details: Set-in, set-on).

Contractor shall detail the protection of the outer surface of the core pipe at Jacket pipe branch steam inlet impingement locations (details of component, material, weld detail shall be identified).

Contractor shall detail the method of change in direction. (Only butt welded, short or long elbows shall be used; longitudinal cutting shall not be allowed).

Contractor shall detail how spacing between inner and outer pipe will be guaranteed (location of spacer, spacer material, the type of spacer, spacer dimensions, quantity of spacers (as a function of length and diameter), spacing of spacers (max. span without spacers shall be 3 meters), weld details to inner pipe.

Contractor shall detail the steam piping jump over details.

The Jacket piping Installation method and sequence shall take into account:

- Cutting of fittings shall not be done and longitudinal welds in jacket pipe shall be kept to a minimum (e.g. only a piece of pipe Max 500mm long may be cut and rewelded).
- visual inspection and non-destructive testing of core pipe.
- pressure testing of both core pipe and jacket pipe.

The requirements specified in 7650-8440-SP-100-0007 shall apply.

The requirements specified in 7650-8440-SP-100-0011 shall apply.

The selection of short radius elbow shall be clearly identified when used for inner bend components.

5.37.3 Inspection

Component and spool fabrication sequence shall allow visual inspection of the core pipe and other required non-destructive testing of the component / spool and welds.

Contractor shall prepare a specific Fabrication Plan and Inspection and Test Plan for jacketed piping.

The requirements specified in 7650-8440-SP-100-0011 shall apply.

5.37.4 Testing

The requirements specified in 7650-8440-SP-100-0010 shall apply.

5.37.5 Steam supply

Contractor shall consider the required steam feed and condensate return arrangement for efficient routing and minimum distance.

Each steam heated circuit shall have a single steam source and dedicated steam trap to ensure a consistent steam supply to the circuit.

The maximum length per steam supply to trap shall not exceed 15m to reduce excessive condensate in pipe.